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ABSTRACT

LICHT, NORMAN CHARLES. A Comparison of Individuals and Dyads in Attaining Relational Concepts. (1971) Directed by: Dr. Bert A. Goldman. pp. 103.

The purposes of this study were (1) to determine whether children attain relational concepts as efficiently when they work as individuals as when they work in dyads; and (2) to compare, as strategies, the choices of the dyads and the individuals in the concept attainment experiments.

The subjects were 192 sixth-grade children that were drawn in equal numbers from each of two elementary schools in the Greensboro, North Carolina Public School System. One of the schools was predominantly Negro, while the other school was predominantly white.

A pretest was administered to all of the 192 subjects in order to (1) assess relational concept attainment within each school; and (2) be used as a training tool. One hundred forty-five subjects worked in the posttest situations after they had been trained in relational concept attainment with informative feedback. Subjects were randomly assigned to one of four treatment groups (two experimental and two control). For statistical purposes an equal number of subjects--48 dyads and 48 individuals--were represented in the posttest situations.

A stimulus array that consisted of 64 instances, in which large and small geometric figures were paired, was used to test relational concept attainment. Subjects were required to find all of the instances in the stimulus array that differed in only one attribute from a problem instance. This task amounted to a demonstration of the knowledge of a concept rather than simply to the discovery of a concept. The task involved finding relationships between several concepts at several different levels before the criterion of the concept attainment task could be reached.

Data were obtained to test null hypotheses regarding main and interaction effects. Analyses of variance were used to determine significant differences within a four-way factorial design.

The following assumptions were accepted after significant differences were found ($P < .05$). In relational concept attainment tasks:

1. Dyads outperform individuals regardless of training.

2. Dyads and individuals select strategies that differ from a preferred strategy.

3. Criterion performance can be successfully achieved by sixth-grade children.

4. The performances of dyads that have been trained as dyads are superior to the performances of individuals or dyads that have been trained as individuals.

The results of the pretest, after applying the t-test, revealed that before training the subjects attending a predominantly Negro school differed significantly in performance from subjects attending a predominantly white school ($P<.01$). The subjects from the predominantly white school showed a higher level of performance. None of the subjects, however, reached the criterion performance for the relational concept task.

The results of this investigation should be of interest to educators responsible for curriculum change, to psychologists responsible for research in cognitive studies of children, and to sociologists concerned with research designs and investigations concerning the dyadic alternative.

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CHAPTER I

INTRODUCTION

> . . . although a problem which resists solution by traditional means may perhaps be insoluble, the probability is rather that those means are themselves inadequate and in need of being transcended in a fresh approach.
>
> (Brewster Ghiselin, The Creative Process)

In the past many experiments have been designed to determine whether persons working in groups are more efficient at problem solving than persons working in individually oriented circumstances.[1] The results tend to show that groups furnish more correct solutions to problems than comparable subjects working as individuals. However, in a number of studies, individuals have outperformed groups. Not only have the results been inconclusive, but there are noticeable gaps in this field of study that remain to be filled.

Almost all of the research effort has been with repetitive tasks that provided little challenge to either the individual or group. Furthermore, the experiments were concerned

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[1] J. F. Dashiell, "Experimental Studies of the Influence of Social Situations on the Behavior of Individual Human Adults," Handbook of Social Psychology, ed. Carl A. Murchison. (New York: Russell and Russell, 1935), 2: 1097-1158; and Harold H. Kelley, and John W. Thibaut, "Experimental Studies of Group Problem Solving and Process," Handbook of Social Psychology, ed. Gardner Lindzey. (Reading, Mass.: Addison-Wesley Publishing Company, 1955), 2: 735-785.

with a simple type of problem-solving task that produced very simple responses. Few of these studies of social interaction have been concerned with more complex situations. In particular, there are few reports of group problems that may have occurred in the course of concept learning. This is surprising, since concept attainment in real life occurs in the course of social interaction--in groups that differ in composition and size.[2]

At the present time there is no conclusive proof that the size of a group is related to concept attainment. This is a matter of importance to teachers, who have long been faced with the following dilemma: whether to teach a person to solve problems alone, or whether social problem-solving situations provide such advantages that they should be adopted.[3]

It has been suggested that if we can achieve a clear understanding of the smallest of the small size groups--the dyad, a two-person relationship--we can subsequently extend our understanding to include the problems of larger and more complex relationships.[4] How the two-person group reacts in the process of concept learning is of special interest to

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[2]M. Sherif, and C. W. Sherif, An Outline of Social Psychology (New York: Harper & Bros., 1956), p. 477.

[3]Robert M. W. Travers, Essentials of Learning. (New York: The Macmillan Co., 1967), p. 369.

[4]J. H. Thibaut, and H. H. Kelley, The Social Psychology of Groups (New York: John Wiley & Sons, Inc., 1959), p. 6.

teachers, particularly as they attempt to arrange social conditions so that concept attainment techniques may be learned.

STATEMENT OF THE PROBLEM

The purposes of this study were (1) to determine whether children attain relational concepts as efficiently when they work individually as when they work in dyads; and (2) to compare, as strategies, the choices of the dyads and the individuals in the concept attainment experiments.

IMPORTANCE OF THE PROBLEM

In the past much of educational research focused upon the individual in school situations. Whatever the case in the past, in the final quarter of the 20th century--in a rapidly changing, complex, and unpredictable culture--much of what is known and expected of the individual in the school, will be changed. Many tasks that an individual has performed adequately by himself will require collaboration with at least one other person before the same level of performance can be attained. Although educators have been aware of this, few educational research investigators have studied the dyad--the two-person group--as a learning and performance team.

There are other benefits to be derived from a study of the dyad. For example, there are advantages to be gained

from investigations in which a dyad replaces the individual, and which focus on the properties of the group as they affect performance. Simmel has suggested that the simplest sociological formation, methodologically speaking, remains that which operates between two elements:

> It furnishes the scheme, germ, and the material for countless more complex formations; although its sociological significance by no means rests merely upon its extensions and multiplications. It is rather itself a socialization, in which not only many forms of socialization realize themselves, purely and characteristically, but the limitation to a duality of the elements is the condition under which alone a certain series of forms of relationship can emerge.[5]

Lewin suggests still another benefit that may be gained from dyadic study:

> That a social unit of a certain size has properties of its own should be expected as a simple empirical fact. If we refuse to see anything magical about it, we will be better prepared to perceive these units correctly and to develop methods for their scientific description.[6]

Few investigators in social psychology have accepted Lewin's injunction to study of the dyad as a social unit.

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[5]Georg Simmel, "The Number of Members as Determining the Sociological Form of the Group." (Translated by A. W. Small) Amer. J. Sociol., (8, 1902), 44.

[6]Kurt Lewin, Field Theory in Social Science (New York: Harper and Brothers, 1951), p. 161.

If the social psychologist worked in, or near the schools, he might be more inclined to engage in such studies. This is because he would be closer to task oriented situations. The importance of the study of dyadic tasks in school situations should not be underestimated despite evidence that there has been no explicit recognition and no analysis of tasks with which the members of the dyad are often concerned. For example, concept attainment is an important school task and appears to be ideal for dyadic study especially because of the recent interest in cognitive studies in either small or large group situations. Yet concept attainment and the dyad have rarely been coupled in research studies.

Carroll reassures us that there are gaps to be filled in such areas of research:

> I suspect that anyone who has examined the concept formation literature with the hope of finding something of value for the teaching of concepts in school has had cause for some puzzlement and disappointment, because however fascinating this literature may be . . . its relevance to the learning of concepts in the various school subjects is a bit obscure.[7]

The selection of an appropriate conceptual task was a critical part of the present study. Since this experiment took place in a school setting, the types of concepts explored,

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[7]John B. Carroll, "Words, Meanings and Concepts," Harvard Educ. Rev., 34 (Spring, 1964), p. 190.

of necessity, had to be those appropriate for children. A second feature of the conceptual task was that it should be of the type obtained in schools. Finally, the conceptual task had to be appropriate for studies that involved groups of dyads, as well as groups of individuals.

Relational concept attainment was the task that met the preceding qualifications. According to common definition, a relational concept deals with the relations among elements of the same concepts. However, typical school concepts are likely to involve relationships between the elements of different concepts. Before one can learn the basic rules of geometry, for example, a rather elaborate structure of prerequisite concepts must be mastered. Initially, these concepts are taught as separate units, and the relationships are emphasized much later. Therefore, relational concept attainment was extended to include the employment of strategies to discover and use relationships, a new and provocative use of the common definition.

When the elements of different concepts consist of numbers, colors, geometric forms, and simple verbal comments, they are likely to appear in typical concept tasks in school. Figure 1 (p. 7) was adapted from the design by Seymore.[8]

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[8] R. Seymore. Strategies in the Utilization of Information. Unpublished Ph.D thesis, Dept. of Social Relations, Harvard. 1954.

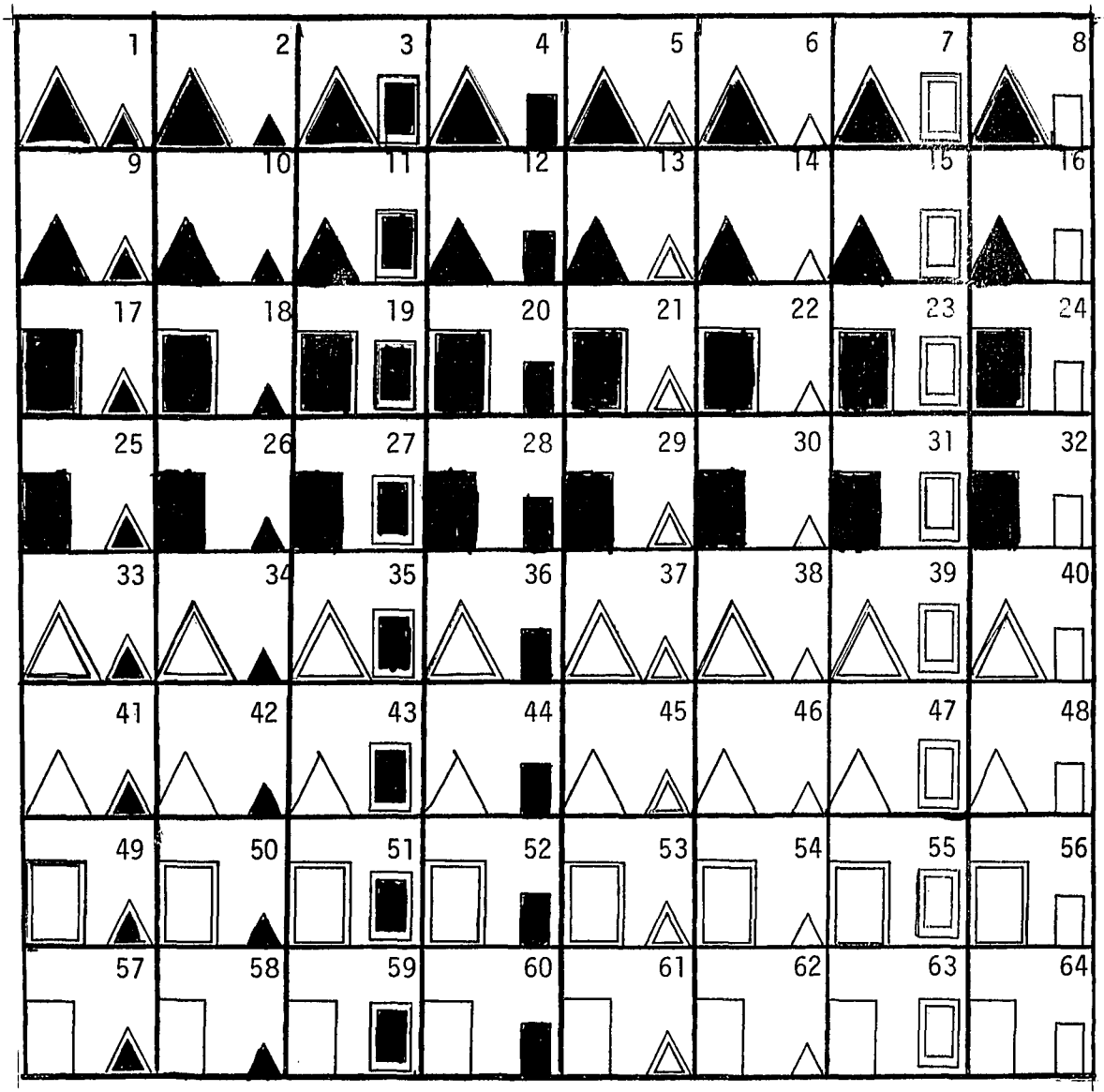

Figure 1. An array of instances comprising combinations of three attributes, each exhibiting two values. Plain figures are in red, solid figures in black.

This figure features an array of elements that satisfies the requirements of relational concept attainment. Since the array could be used with groups, as well as with individuals, it was adopted for use in the present study.

In summary, tests of the dyad in relational concept attainment, within controllable and reproducible situations in the school, should contribute to a further understanding of complex social behavior. These studies should also provide practical data for the educator who seeks to improve teaching and learning in the schools.

DEFINITION OF TERMS

Attribute. Within this investigation an attribute will be interpreted as meaning any descriptive feature of an object that can be observed to vary from object to object.[9] By stating that an attribute may vary, it is implied that any attribute represents a dimension along which one may specify values. For example, color is an attribute, while specific colors such as green, red, etc., are values.

Concept. A concept exists whenever objects have been grouped or classified together and set apart from other objects;

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[9]J. S. Bruner, J. J. Goodnow, and G. A. Austin, A Study of Thinking. (New York: John Wiley & Sons, Inc., 1956). p. 26.

such a grouping is generally limited to the most common properties of the objects. Concepts do not exist in isolation; they depend for their definition upon the social interactions of people.[10] Concepts, then, rely upon a behavioral definition, which is operational, that is, a definition that will indicate the responses necessary for the attainment of the concept. Concept attainment is said to have occurred "when a person is able to make the same response to dissimilar stimuli."[11]

Figure 1 (p. 7) is a chart that comprises many different concepts. This figure displays an array of stimulus objects, which can be grouped and also set apart from each other, in terms of numbered instances. The objects vary in three attributes: in shape (square or triangle), in color (red or black), and in border (one or none). Every numbered instance in the array includes two objects (large and small), each of which contains a combination of the three attributes.

When concepts are learned in school, they often depend upon the attributes, which themselves represent difficult concepts. "In more general terms, concepts learned in school

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[10] M. Sherif and C. W. Sherif, An Outline of Social Psychology. (New York: Harper & Bros., 1956), p. 477.

[11] Benton J. Underwood, Experimental Psychology. (New York: Appleton-Century-Crofts, 1949), p. 591.

often depend upon a network of related concepts."[12]

Dyad. Two persons may be classified as a dyad when face-to-face relations between them have persisted over a length of time which is sufficient to establish that a pattern of cooperation has occurred. A characteristic of such pairs, as described by Becker and Useem, is that the "two individuals must cooperate for the achievement of some end which is regulated by an individual or group other than the members of the pair."[13] Within the context of this report, the dyad will mean a two-person group that has been brought together for the principal purpose of concept attainment.

Informative feedback. In conceptual problems, the solution is a concept which is put to use in some way. "The attainment of solution," according to Bourne, "is ordinarily a guided process."[14] Conventionally, the problem solver receives clues from his environment. If properly interpreted, the clues can be used to arrive at a correct solution. These clues are referred to as informative feedback. Someone in the environment, or the environment itself, feeds (gives) back to

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[12]Carroll, op. cit., p. 190.

[13]Howard Becker and Ruth H. Useem. "Sociological Analysis of the Dyad." Amer. Soc. Rev., 7, 1942, 16.

[14]Lyle E. Bourne, Human Conceptual Behavior. (Boston: Allyn and Bacon, Inc., 1966), p. 5.

the problem solver information about the correctness of one or more of his responses.

Relational concept attainment. Relational concepts are defined by connected or related attributes from which a class identity is inferred. As for class membership, "the relational class is one in which the rule of inference requires that values of different attributes bear a specified relation to each other."[15] An examination of the task of relational concept attainment shows that the subject is required to go beyond the simple task of recognizing relations and to use strategies in recognizing perceptual relationships among objects. (By perceptual relationships are meant differences or similarities in form or color.)[16] The subject demonstrates this more complex task, attainment of the concept, when he responds appropriately to stimuli at a specified level of accuracy. In this experiment the subject is presented with a stimulus array and is required to list all possible instances that differ from a given instance by either one attribute, or one value of an attribute. An example of a relational concept attainment

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[15]Bruner, Goodnow, and Austin, op. cit., p. 244.

[16]Benton J. Underwood, "An Orientation for Research on Thinking." Psychol. Rev., 1952, 209.

problem is described below:

Problem: Study the array of Figure 1 and list all of the instances that differ in only one respect from instance number six.

Answer: There are six instances that qualify as answers to this problem: 2, 5, 8, 14, 22 and 38.

Strategy. This term is a description of regularities in decision making. "A strategy refers to a pattern of decisions in the acquisition, retention, and utilization of information that serves to meet certain objectives, that is, to insure certain forms of outcomes."[17]

An aim of the present study was to externalize for observation the decisions in concept attainment in anticipation that regularities in these decisions might provide the basis for making inferences about the processes involved in attaining a concept. In this experiment the concept was given and the subjects had to find all of the examples of the concept. In this special view of relational concept attainment, a strategy was inferred from the pattern of correct choices of attributes.

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[17]Bruner, Goodnow, and Austin, op. cit., p. 54.

Preferred Strategy. The preferred strategy is a technique of varying each of a number of factors in succession while holding one factor constant.[18] This term is an analytical device: prescribed answers, or choices, that serve as a yardstick against which to compare the performances of children. In this study the prescribed choices that represented the preferred strategy followed a rule (adapted in part from studies by Heidbreder and her associates) of selecting an instance by shape first, color next, and border last. This rule was used in comparing performances in an effort to acquire specific information concerning the strategies of decision making.[19]

Transfer of Training. This phrase may be described as the influence of prior learning or experience in one task on the performance of another task.[20] Transfer of training in the present experiment, refers to knowledge that is acquired in training and utilized in a subsequent concept attainment situation.

All of the above words or terms were defined to tie in closely with the particular problem at hand.

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[18] Ibid., p. 81-125.

[19] E. Heidbreder, M. L. Bensley, and M. Ivy, "The Attainment of Concepts. IV, Regularities and Levels," J. Psychol., 25(1948), 299-329.

[20] Bourne, op. cit., p. 97.

PLAN OF THE DISSERTATION

Chapter II, "Review of the Literature," contains some of the research studies that have been conducted in the areas which are related to the present study.

Chapter III, "Methods and Procedures," includes the following: (1) Experimental Problems, (2) Assumptions and Hypotheses, (3) Selection of Subjects, (4) Materials, (5) Procedures and Statistical Design.

Chapter IV, "Treatment of Results," consists of statistical analyses and interpretations of the experiments.

Chapter V, "Findings, Conclusions, and Recommendations," describes the findings, the conclusions drawn from the study, and recommendations for future research.

CHAPTER II

REVIEW OF THE LITERATURE

This chapter is intended to be a brief summary of the theory and research of problems which are closely related to the present study. The review has been divided into the following sections: Literature on the Theory of the Dyad as a Special Group; Experimental Studies of the Dyad; and Research in Relational Concept Attainment.

LITERATURE ON THE THEORY OF THE DYAD AS A SPECIAL GROUP

This section deals with the speculations of social scientists that the dyad constitutes a special-size group. Georg Simmel, one of the principal founders of modern sociology, emphasized that the dyad has a unique structure that may be dissolved under certain conditions. This is a characteristic of the two-person group which apparently does not extend to groups of other sizes. It was over 60 years ago when Simmel made the following observation about the decisive characteristic of the dyad: "each member must actually perform something, and that, when he refuses to do this, only the other remains without any super individual energy such as, even in the case

of a combination of only three, is in some measure present."[1]

In a more recent essay, Becker and Useem reiterated Simmel's notion. They also suggested that other changes may occur as a result of the loss of a member of a pair: "In larger associations, the departure of one member does not result in demise of the structure, but in the dyad such a loss not only destroys the pattern but also results in changes, sometimes radical, in the personalities of the two."[2]

Caplow holds a similar point of view, although his focus is somewhat different. He says that "a dyad cannot ordinarily constitute an organization because it has no collective identity apart from its two principals. Replacing one of the couple creates a new couple, not a continuation of the old one."[3]

Becker and Useem, in attempting to point out the uniqueness of the dyad, assert that "all dyads eventually become broken dyads."[4] This hypothesis suggests that all two-person groups are destined to be dissolved. It also implies that apparently viable dyads are actually in a stage of dissolution.

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[1] Simmel, op. cit., p. 45.

[2] Becker and Useem, op. cit., p. 16.

[3] Theodore Caplow. Two Against One. (Englewood Cliffs, N. J.: Prentice Hall, Inc., 1968), p. 9.

[4] Becker and Useem, op. cit., p. 16.

This hypothesis, however, continues to be mere speculation, due to a lack of experimental research.

A report on the unique aspects of the dyad is credited to Bales and Borgatta. As a result of the data derived from a comprehensive study of group size,[5] the dyad appears to have the following unique characteristics: (1) notably high rate of showing tension; (2) low rates of showing disagreement and antagonism; (3) asking for orientation is uniquely high; (4) giving opinion is low; and (5) asking for opinion is high. These conclusions are drawn from a matrix table known as the Interaction Profile, an instrument designed by Bales to record and analyze social interaction. There is some question as to whether results from this special series of tasks and subjects warrants a generalization of unique qualities of the dyad. It appears that the subjects were limited to college students and the task was restricted to a discussion of a human relations case.

In a current publication, Bales expressed many of the same conclusions:

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[5]Robert F. Bales and Edgar F. Borgatta. "Size of Group as a Factor in the Interaction Profile," cited in Small Groups, edited by A. Paul Hare, Edgar Borgatta and Robert F. Bales (New York: Alfred A. Knopf, 1955), 402.

> when experimentally formed dyadic groups with no clear definition of their relationship are asked to come to a common decision on a problem, they show features not common to similar groups of larger sizes. Groups of two are markedly low on showing disagreement and unfriendly behavior but markedly high on showing tension and asking for information. They appear to take extra care to avoid conflict and to persuade each other gently. In such a group, either member may exercise a complete veto by withdrawal, refusal of cooperation, or the like . . . in an isolated group of two, each member of the pair is unusually vulnerable to the other.[6]

This pattern is consistant with an interpretation of the dyad, as in ad hoc[7] experimental groups, where there are few group norms to which both members of the pair agree. In such cases the dyad is in the unique position of building a common set of norms. There is no majority or super authority to which either member of the group may appeal. Hare supplies the following view of the dyad in such situations:

> The task of building a common set of norms in this situation is apparently an anxiety-provoking prospect, and tends to be avoided or in part glossed over by agreement on more specific and superficial matters... The two-man group may be viewed as having built into it an implicit agreement that the two members will stay within spheres on which they can agree. However, there is a strong tendency for two asymmetric roles to develop... for one member to gravitate toward a more active role and exercise the power of initiative while the other tends toward a more passive role and holds the power of veto.[8]

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[6] Psychology Today - An Introduction. Edited by B. F. Bales et al. (Del Mar, Calif.: CRM Books, Inc., 1970) p. 603.

[7] An ad hoc group is one which may be assembled for a particular purpose and then dismissed.

[8] A. Paul Hare. Handbook of Small Group Research. (New York: The Free Press of Glencoe, 1962), p. 241.

Not all researchers agree that the size of a group is the factor that contributes in larger measure to the uniqueness of the group. For instance, Thibaut and Kelley, co-authors of a functional view of social behavior, which utilizes the dyad in its theoretical formulations, make the following comment:

> Purely physical variables readily manipulable, like size, have a way of presenting themselves to the researcher's attention particularly in the absence of good theory. For social engineering purposes the importance of the variable is indisputable. But size itself may have distinct limitations as a variable with clear theoretical significance.[9]

Thibaut and Kelley readily admit to a bias on the issue of group uniqueness:

> In the analysis that follows we begin with the two-person relationship, the dyad. We so begin in order first to attempt to understand the simplest of social phenomena by endeavoring to be as clear and explicit as we can about the conditions necessary for the formation of a dyadic relationship . . . Our bias on this point is apparent: We assume that if we can achieve a clear understanding of the dyad that we can subsequently extend our understanding to encompass the problems of larger and more complex relationships.[10]

Later in this book, they admit to certain problems which may exist for all groups other than dyads. This implies a certain uniqueness for the dyad. They write the following: "clearly, if either person leaves a dyad, the

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[9]Kelley and Thibaut, op. cit., p. 761.

[10]Thibaut and Kelley, op. cit., p. 6.

dyad no longer exists."[11] And further on they relate:

> We do not propose to make any serious assault on the classical problem of group identity. Let us merely suggest that if the group's resources enable it to withstand the loss of several members, without very dramatic changes in its structure or functioning or in the outcomes achieved by the remaining persons, we might decide to consider this collectivity as maintaining its own identity even though there are minor fluctuations in the size and composition of the group.[12]

The dyad has been viewed as a unique group from a theoretical point of view. Although there is consensus that the dyad is unlike other groups, there is little evidence to support this theory. In the next section, some of the current experimental work is examined.

EXPERIMENTAL STUDIES OF THE DYAD

Until recently few publications have been concerned with dyadic experiments. In the past ten years, the dyadic literature has expanded, due directly to the special interest in experimental games. The gaming studies, however, constitute a special category of dyadic investigations that only indirectly relate to the present investigation Therefore, this brief summary of the experimental work on dyads is presented in two sections: Non-Gaming and Matrix-Games.

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[11] Ibid., p. 192.

[12] Ibid.

NON-GAMING

Klugman, in attempting to discover whether two heads were better than one in problem solving, directly attacked the problem of dyadic performance on arithmetical tasks.[13] This investigation is noteworthy for several reasons: (1) the subjects were children who were matched and equated according to their sex, race, grade, age (within three months), and IQ (within four points); (2) the results indicated that dyads performed better than individuals, but took more time in doing so; (3) the dyads in some, but not all subgroups (i.e. both sexes, 6th graders and whites), earned higher scores than individuals; and (4) the higher scores for dyads and the longer time needed to solve the problems were both due to the interactions that occurred when members of the dyad were working together on the problems. However, many of the dyads were only able to solve fewer than half of the arithmetic problems (mean number of correct solutions for the superior groups was 7 of a possible 20). Nowhere in the study is there a mention of any informative feedback that occurred between the testing of subjects. Nonetheless, much of Klugman's methodology appears to be applicable in future studies.

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[13]Samual F. Klugman, "Cooperative versus Individual Efficiency in Problem Solving," J. Educ. Psychol., (35, 1944), 91-100.

Taylor and Faust used the familiar parlor exercise known as Twenty Questions as a test of problem solving on individuals and groups of two and four.[14] The major question of the experiment involved the relation between efficiency in problem solving and size of group. The results showed that in terms of number of questions, number of failures, and elapsed time per problem, the group performances were superior to individual performance; but the performance of groups of four was not superior to that of the dyads. It is interesting to note that in terms of the time[15] required for problem solution, the performance of individuals was superior to that of either size group, while the dyads outperformed the four-member groups. Taylor and Faust have found that dyads may outperform individuals but just as Klugman's experiments revealed, it may take the dyads longer to do so:

> It appears probable that there are many kinds of problems which a group will solve more quickly than an individual. If elapsed time...is the primary consideration, then such problems should be undertaken by groups. However, it appears equally probable that few of those same problems will be solved more efficiently in terms of man-minutes or man-hours by groups than by individuals. If a group of two is to solve a problem more efficiently than an individual in these latter terms, it must solve it in less than half the elapsed time required for the individual...The importance of this point appears to be frequently overlooked.[16]

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[14]Donald W. Taylor, and William L. Faust, "Twenty Questions: Efficiency in Problem Solving as a Function of Size of Group," J. Educ. Psychol., (44, 1952), 360-368.

[15]Solution time is calculated in man-minutes. The number of man-minutes for a problem is equal to the elapsed time multiplied by the number of persons in the group.

[16]Taylor and Faust, op. cit., p. 367.

When the performances of the dyad and four person groups were compared with individuals by Klausmeier, Weirsma, and Harris,[17] the results were in agreement with earlier studies which failed to establish a clear superiority of groups over individuals. In this experiment of concept acquisition, college students served as subjects. They worked as individuals, in dyads, and groups of four, and were tested on the performance of an immediate and delay transfer problem. The important methodological contribution of this experiment was the design which enabled the testing of the effects of initial learning conditions upon subsequent performance. The authors suggested that "in future experiments designed to assess the quality of performances of individuals and of groups of varying size, the experimenters should be concerned not only with performance in the initial situation but also in a subsequent one."[18] A substantive result of this experiment was that initially pairs performed more efficiently than individuals, but those who learned originally as individuals performed significantly better than those who learned in dyads when all subjects worked as individuals.

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[17]Herbert J. Klausmeier, William Weirsma, and Chester W. Harris, "Efficiency of Initial Learning and Transfer by Individuals, Pairs, and Quads," J. Educ. Psychol., (54:3, 1963), 160-64.

[18]Ibid., p. 164.

Goldman's study of the dyad is noted for its unusual methods of pairing subjects.[19] After an initial test was administered to individuals, dyads were formed on the basis of the first administration so that the following conditions were true for each of the pairs:

> there existed three items on which both subjects had obtained the same wrong answer; there were three items on the initial test which both subjects got right; there were three items on which both subjects had obtained different wrong answers; and there were three items where one subject had obtained the right answer.[20]

Goldman found that the performance of a dyad was not always superior to that of an individual. According to Goldman, group performance depended upon whether individual subjects tended to solve problems correctly.

> If the problems are such that both members of the pair group have a tendency to solve them correctly, then the group members will tend to reinforce each other in the correct solution to the problem. On the other hand, if the problems are such that members of a paired group would each have the tendency to get them wrong, choosing the same incorrect response, then the group would do worse than a single individual with the same tendency to get the problem wrong.[21]

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[19] Morton Goldman, "A Comparison of Group and Individual Performance Where Subjects Have Varying Tendencies to Solve Problems," J. Per. Soc. Psychol., (3:5, 1966), 604-607.

[20] Ibid., p. 605.

[21] Ibid., p. 607.

This experiment was an effort to confirm the results of an earlier study conducted by Goldman. That investigation showed that dyads performed better than individuals working alone.[22]

MATRIX-GAMES

An examination of matrix-games offers an opportunity to investigate some very unique social-interaction processes that may occur between two persons. A number of studies in dyadic behavior have been stimulated by Tucker,[23] and by Rapaport and Chammah,[24] whose book describes the two-person matrix-game known as the prisoner's dilemma. This is a dyadic game of research that investigates cooperative and competitive behavior in a role playing situation.

Players in the game assume the roles of two prisoners who have been arrested for the same crime and who are being held incommunicado. Each prisoner is given a series of choices with a scaled series of rewards and punishments, so that their effects on cooperative and competitive behavior can be studied systematically. There are four possible outcomes on any single

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[22]Morton Goldman, "A Comparison of Individual and Group Performance for Varying Combinations of Initial Ability," J. Per. Soc. Psychol., (1, 1965), 210-216.

[23]A. W. Tucker, Game Theory and Programming, Department of Mathematics, (Stillwater, 1955, The Oklahoma Agriculture and Mechanical College), mimeographed.

[24]Anatol Rapaport and Albert M. Chammah, Prisoner's Dilemma: A Study in Conflict and Cooperation. (Ann Arbor, 1958, University of Michigan Press).

trial and these four outcomes make up a matrix of four cells in a two-by-two contingency table, which can be conveniently analyzed (Figure 2, below).

The two players have two alternatives: to confess or not to confess. Since the greatest benefit to each prisoner is derived from non-agreement, this game is properly called non-cooperative. The matrix, however, may be changed so that the players would benefit from agreement. Then, this game could be called cooperative.

PRISONER 1	PRISONER 2	
	NOT CONFESS	CONFESS
NOT CONFESS	1 YEAR EACH	10 YEARS FOR 1 3 MONTHS FOR 2
CONFESS	3 MONTHS FOR 1 10 YEARS FOR 2	8 YEARS FOR BOTH

Figure 2. Payoff matrix in a version of the "Prisoner's Dilemma." Adapted from R. Luce and H. Raiffa. Games and Decisions, (New York: John Wiley & Sons, Inc., 1967), p. 95.

Game experiments may be viewed as possessing a potential social research value in education. For example, two students may interact in response to a task set by the teacher. To this situation is added the possibility that each student will exercise some control over the other. Such reciprocal controls could also extend to situations that involve the teacher and an individual student. A research design to test this phenomenon remains as an important consideration in future investigations of dyads and individuals.

Bruner, Goodnow, and Austin have referred to threads of game theory throughout their work.[25] However, they considered such theory incidental to their attempts to describe concept attainment. In the same work, they indicated that:

> the hidden aspect of the definition of a task in concept attainment is the two-man feature of most experimental research on the thought process ... Subjects tend to define their task as one in which their abilities are under test. As a result, an error may take on different consequences and the effect may be to lead the subject to play safe in the instances for testing.[26]

This was an issue that Bruner and his associates failed to resolve. They carefully avoided it by saying "we cannot

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[25]Bruner, Goodnow, and Austin, op. cit., p. 23

[26]Ibid., p. 58-59.

settle this vexing problem here, but wish only to point it out as a ubiquitous and important factor in determining the behavior of subjects in experiments on the thought process."[27] Apparently the play safe syndrome is another of the dyadic dilemmas that is left for future researchers to resolve.

This section ends with the report of a study that is unlike the other dyadic gaming investigations. Yet, it will be observed that the study concerns pairing subjects; a topic that is a crucial part of the present problem.

In a gaming type experiment which has become a classic for social psychologists, Asch demonstrated a strong tendency for an individual to conform to group pressure even when the group appeared to be making obvious mistakes.[28] However, when the individual was given the support of a truthful partner, the presence of the partner deprived the majority of much of its power. The pressure on the individual to conform was reduced to one-fourth: that is, subjects answered incorrectly only one-fourth as often as under the pressure of a unanimous majority. Asch found that as long as the subject had someone on his side, he was almost invariably independent, but as soon as he found himself alone, there was a tendency to

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[27] Ibid., p. 59.

[28] Solomon E. Asch, "Effects of Group Pressure Upon the Modification and Distortion of Judgments," in Groups, Leadership and Men, edited by Harold Guetzkow. (Pittsburgh: Carnegie Press, 1951), p. 171-190.

conform to the majority. One effect of pairing may be to elevate the performance of individuals. This remains a question to be confirmed in dyadic investigations.

RESEARCH IN RELATIONAL CONCEPT ATTAINMENT

The relational concept attainment studies which are reviewed in this section are specially grouped and listed under the following sub-headings: Task Definition; Strategy Preference; Transfer of Training; and Studies Dealing with Children.

TASK DEFINITION

Research shows that a subject's performance in concept attainment is affected when the subject is not told what the nature of his task is to be. In a classic investigation, Hull employed rote-memory instructions, leading his subjects to believe that their task was to memorize the labels of different figures presented to them, rather than to seek to discover what were the defining properties of instances bearing the same labels.[29] The subjects of Hull's study were not told to focus upon relevant aspects of the

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[29]Clark L. Hull, "Quantitative Aspects of the Evolution of Concepts," Psychol. Monogr., 28, No. 1, (Whole No. 123), 1920.

instances presented to them. They were told to learn to associate nonsense syllables with different sets of pseudo-Chinese characters. But, hidden within these characters was a radical that was a defining attribute of the correct concept. The point of the experiment was to see whether successive lists of characters could be learned in an efficient manner as subjects were given more and more experience with basic radicals. The result showed that less time was required for subjects to learn each new list. The subjects came to form concepts in the sense that they generalized on the basis of the key radicals in the different characters.

It is understood that Hull's purpose in conducting the study was to gain knowledge about the manner in which subjects abstract attributes from a complex situation. However, what has been overlooked is that the radicals represented different concepts that were related to each other by the subtle differences in the radicals. This experiment may be interpreted as a test in relational concept attainment in which the subjects were unaware of their real task.

Reed found that concepts are learned more readily and retained longer if the subject is told in advance that concepts are to be formed.[30] Reed explained his findings by stating

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[30]H. B. Reed, "Factors Influencing the Learning and Retention of Concepts," I. The Influence of Set. J. Exp. Psychol., 36, 1946. p. 71-87.

that subjects, who knew their task beforehand, could formulate and test hypotheses about concepts more freely, than if the subjects were not informed of the task.

In experiments where the goal is to transform and control information, it is important that the task be well defined to the subjects. Bruner declares:

> so long as the experimenter does not know to which, and to how many, component attributes the subject is attending, it is impossible to control or understand the amount of information being presented to the subject by any one instance or combination of instances.[31]

STRATEGY PREFERENCE

According to Hunt: "A strategy is a plan for arriving at a predefined goal at a minimum cost."[32] It is of interest to explore the strategies that subjects prefer to employ in attaining concepts. Strategies may be appropriate descriptions of human concept attainment. Consequently, they may be revealed by means of experimental situations that are designed to support or hinder them.

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[31]Bruner, Goodnow, and Austin, op. cit., p. 135.

[32]Earl B. Hunt. Concept Learning. (New York: John Wiley & Sons Inc., 1962), p. 163.

Seymore,[33] and Bruner and his colleagues,[34] report that when instances of an array of geometric forms are arranged so that instances are in an ordered pattern rather than in random order, subjects will likely adopt a more efficient strategy and solve a conceptual problem. Seymore's study, moreover, shows that persons are quite capable of adopting a strategy which is suited to the particular concept attainment task. These investigations, in general, were concerned with the attainment of conjunctive concepts. There were few studies of relational concept attainment included in their reports. The present investigation, however, was undertaken to help remedy this situation.

Shepard, Hovland, and Jenkins[35] employed a relational concept in an experiment that tested the strategy preferences for solving a conceptual task. The experiment utilized figures that had a single common attribute. It is important to note that those subjects who solved the problem showed no special preference for relational strategies.

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[33] Seymore, op. cit.

[34] Bruner, Goodnow, and Austin, op. cit., p. 96.

[35] R. N. Shepard, C. T. Hovland, and H. Jenkins, "Learning and Memorization of Classifications," Psychol. Monogr., 73 (Whole No. 517) 1961.

Hunt has observed that "the presence of a relational answer complicates the interpretation of that experiment."[36] This may be one reason why there are few studies that deal with strategy preference in combination with relational concepts.

TRANSFER OF TRAINING

Bourne has suggested that "one way to evaluate the effectiveness of an educational experience is to determine the extent to which it transfers positively to other situations."[37] However, clear and unambiguous transfer studies are rarely achieved. "And one is tempted to remark, how little we know about transfer of training."[38]

Depending upon the characteristics of the original training and transfer tasks, the effects that carry over may be positive, negative, or negligible. Performance on the second task may be better than, worse than, or no different from what it would have been without practice on the first.[39]

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[37]Bourne, op. cit., p. 98.

[38]Robert M. Gagne, "Problem Solving," in Categories of Human Learning. Edited by Arthur W. Melton. (New York: Academic Press, Inc., 1964), p. 311.

[39]Bourne, op. cit., p. 97.

In a study conducted by Anderson, it was demonstrated that when presented with suitable training, children will acquire and transfer a rather advanced complex problem solving skill. A training procedure employing programmed instruction techniques was used to teach high I.Q. first graders to solve problems by varying each factor in succession while holding all other factors constant. The results indicated that, contrary to prominant developmental theories, children did acquire, retain, and transfer problem solving skills when presented with suitable training.[40]

There is another dimension to transfer of training that should not be overlooked. There is often more than one acceptable correct solution to a concept attainment problem. Wells explored this possibility.[41] The results of his experiments indicated that a moderate amount of training on disjunctive[42] concept problems increases the probability that subjects will offer the disjunctive solution to the problem for which a conjunctive solution is also possible. Wells suggests that, although previous experiences with concepts

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[40]Richard C. Anderson, "Can First Graders Learn an Advanced Problem-Solving Skill?" J. Educ. Psychol., 56:6 (1965), pp. 283-294.

[41]Herbert Wells, "Effects of Transfer and Problem Structure in Disjunctive Concept Formation," J. Exp. Psychol., 65:1 (1963), pp. 63-69.

[42]A disjunctive concept is one that states that an instance is positive if it has either of two elements.

probably produces an initial favoritism for one particular concept attainment solution (conjunctive), this preference can be overcome by moderate degrees of training in another type of concept attainment solution (disjunctive).

Much of the positive transfer in conceptual problem solving is attributable to the carry over of general elements of strategy, orientation, and adaptation to the problem. Systematic instruction in approach (a major consideration in the present investigation) has been shown to facilitate both motor learning[43] and memorization.[44] French demonstrated that a general principle is more transferable than is rote memorization of the solution for a given class of problems.[45]

The importance of an understanding of basic relationships for positive transfer in specific school subjects has been demonstrated.[46] But what is now needed is a series of

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[43]C. P. Duncan, "Transfer after Training with Single versus Multiple Tasks," J. Exp. Psychol., 55(1958), 63-72.

[44]H. Woodrow. "The Effect of Type of Training upon Transference." J. Educ. Psychol., 18(1927). 159-72.

[45]R. S. French, "The Effect of Instructions on the Length-Difficulty Relationship for a Task Involving Sequential Dependency," J. Exp. Psychol., 48(1954), 89-97.

[46]W. A. Brownell, and H. E. Moser, "Meaningful versus Mechanical Learning: A Study in Grade III Subtraction," Duke University Res. Stud. Educ., 1949, No. 8.: and Esther J. Swenson, "Organization and Generalization as Factors in Learning, Transfer, and Retroactive Inhibition," in Learning Theory in School Situations. University of Minnesota Studies in Education. Minneapolis: University of Minnesota Press, 1949. 9-39.

empirical studies that demonstrate transfer of training in problems of concept attainment, which may extend beyond the confines of the particular discipline in which they are encountered.

STUDIES DEALING WITH CHILDREN

Piaget views a concept as an explanatory rule by which a relation between two or more events is described.[47] He did not think that it was necessary to assign labels or names to concepts, in order to describe the child's ability to manipulate relations among objects or symbols of objects.

Although Piaget views relational thinking as almost non-existent in children under seven, he thought that children, by the age of eight, should be able to notice differences between symbols; that is, at about this time, subtracting of attributes should come within the capabilities of the child.[48] Consequently, a relational concept attainment task should be manageable by children of eight years and above.

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[47] J. Piaget. The Child's Conception of the World. (New York: Harcourt, 1929).

[48] J. Piaget. The Child's Conception of Number, translated by C. Gattegno and F. M. Hodgson (London: Routledge, 1952).

Furthermore, Piaget has demonstrated that children of eleven and older are capable of holding one or more factors constant while varying one factor at a time to see if there is a correspondence (relationship) between them.[49] This technique, which has been described as a classical conceptual strategy in experimental science, has been explored in only a limited way by Piaget. His major intention has been to show that children, who demonstrate this relational skill, are exhibiting formal thought and have progressed from an earlier stage (concrete operations). Piaget explains the transition from the concrete thought of the child to the formal thought of the adolescent as distinguished by the development of new strategies and concepts, which are not restricted to the classes and relations that make up their content. The present experiment is an effort to study the questions raised when the children demonstrate the operations of formal thought.

Heidbreder and her colleagues have found that concepts tend to be attained in this order: form, color, and number.[50] In addition, Heidbreder found that concepts evolved more

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[49]Barbel Inhelder, and J. Piaget. The Growth of Logical Thinking From Childhood To Adolescence, translated by Anne Parsons and Stanley Milgram (New York: Basic Books, Inc., 1959), p. 54.

[50]Heidbreder, Bensley and Ivy, op. cit., 299-300.

easily from pictured than from verbal materials. She indicated, in another study, that the readiness with which a concept is formed is determined by the relationships between its referent and the perceptual situations in which it is presented.[51] It appears that relations between meaningful symbols are important in performance on concept attainment. While Heidbreder has conducted her experiments mainly in college settings and with college students, her findings appear to be applicable to investigations that involve the attainment of concepts by children.

A child's view of middleness--a generalized concept of middle sized objects--was examined in a series of relational studies of shape, size and position. Graham and his colleagues found that the concept of middleness increases between the ages of seven and nine years.[52]

Kagan and Lemkin studied the conceptual preference of children. The findings indicate that for boys, as well as girls, form was distinctly preferred to color and color was preferred to size.[53] However, some differences were found.

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[51]E. Heidbreder, "Language and Concepts," Psychol. Bull., 33(1936), abstract, 724.

[52]V. Graham, T. A. Jackson, L. Long, and L. Welch, "Generalizations of the Concept of Middleness," J. Genet. Psychol., 65(1944), 227-237.

[53]Jerome Kagan and Judith Lemkin, "Form, Color, and Size in Children's Conceptual Behavior," Child Developm., 32(1961), 25-28.

For boys, there was no age difference in the response patterns. However, when compared to younger girls, nine-year-old girls were less likely to use color as a basis for conceptualization. Older boys were more likely to use color than older girls. These results suggest that girls have a preference in strategy that is different from that of boys. Although sex was not considered a major factor in the present study, it is recommended that boys and girls be compared in future research.

In another study on relations of objects, Emmett has found that ability to perceive two diminesions is closely related to general intelligence. His studies showed boys superior to girls in a variety of space performance tests. Emmett believed his results give evidence of a space factor in children's abilities.[54]

Hudgins conducted a number of experiments[55] in an effort to answer the following two questions: First, do children working together in groups learn techniques of problem solving which they can apply later in similar situations? Secondly, does interaction contribute to the superiority of group problem

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[54]W. C. Emmett, "Evidence of a Space Factor at Eleven and Earlier," Brit. J. Psychol., 2(1949), 3-16.

[55]Bryce A. Hudgins, "Effects of Group Experience on Individual Problem Solving," J. Educ. Psychol., (51,1; 1960) 37-42.

solving? This study involved 128 fifth-grade girls and boys who were matched for mental ability. The study lasted three days during which subjects worked on sets of arithmetic problems. In answer to question one, group members solved significantly more problems than subjects who worked alone. However, the answer to the second question of this study was inconclusive. Group experience apparently does not enhance individual problem solving. In the discussion of his study, Hudgins implied that individual mental ability and leadership were critical to group problem solving. He contends, "The problem solving superiority of small groups depends upon the efforts of the most able member of the group to communicate his knowledge to others, and upon the degree to which he achieves acceptance of his solutions." Furthermore, he concludes that "if this hypothesis proves tenable, transfer from the group to the individual situation would not be expected to occur."[56] This is a startling suggestion, for the major reason of arranging learning and teaching teams is to promote individual performance. The idea that a group that learns as a group should be tested as a group, bears investigation.

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[56] Ibid., p. 42.

Vinacke has compiled a series of studies showing that scores on various kinds of concept tests correlate only moderately with intelligence, thus indicating that conceptualizing is at least not identical with general intelligence. Vinacke has found that when a child is about eight years old, the youngster starts to display behavior that indicates a marked development of concepts pertaining to social objects. Furthermore, this ability grows with age. However, as a caveat intended for teachers, Vinacke carefully qualifies the preceding generalizations:

> the relation to age should not be taken to mean that intelligence is not significant. Two children of the same age who differ in intelligence, but for whom experience is held constant, would probably differ in the quality of their conceptualization. The truth is that more investigation is needed before we can be sure of the comparative roles of experience and intelligence in the acquisition and use of concept.[57]

Vinacke warns teachers to be wary of overemphasizing intelligence, to the exclusion of experience, in the crucial area of concept attainment.

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[57]W. Edgar Vinacke, "Concept Formation in Children of School Ages," Education, (May, 1954). 532.

SUMMARY

The initial review in this chapter dealt with the literature which focused on the special-group theory of the dyad. It was discovered, through the early writings of sociologists and psychologists, that the dyad is an unique group, quite different from other groups. From a consideration of these early deductions, it was decided that the next area explored should include empirical and experimental studies. These studies were presented in two sections: Non-Gaming and Matrix-Games. Some of the more important findings were that dyads usually outperform individuals, and dyadic games may be adopted for experimental use in school settings. The third survey of literature reviewed relational concept attainment studies in several categories: Task Definition; Strategy Preference; Transfer of Training; and Studies Dealing with Children. Throughout the course of the review, some general assumptions were made. They were used as a basis for establishing testable hypotheses. That part of the problem is pursued in greater detail in the next chapter, "Methods and Procedures."

CHAPTER III

METHODS AND PROCEDURES

In the preceding chapter several research studies were reviewed. A major objective of the review was to examine the research data that led to a formulation of logical assumptions and testable hypotheses.

The general purposes in formally stating the assumptions were (1) to firmly establish the framework within which this investigation would take place; and (2) to aid in the development of hypotheses which would be amenable to experimental testing. Ultimately, the goal was to test the relationships that were indicated in the hypotheses.

The working design of this experimental study consists of the following sections that fall under the general heading of "Methods and Procedures": Experimental Problems; Assumptions and Hypotheses; Selection of Subjects; Materials; and Procedures and Statistical Design.

EXPERIMENTAL PROBLEMS

Two experimental problems were stated initially in Chapter I (p. 3) and for convenience are restated here:

(1) to determine whether children attain relational concepts as efficiently when they work as individuals as when they work in dyads; and (2) to compare, as strategies, the choices of the dyads and the individuals in the concept attainment experiments.

ASSUMPTIONS AND HYPOTHESES

The following logical assumptions relate to the present problem. It is probable that:

(a) dyads will outperform individuals in concept attainment tasks.

(b) in relational concept attainment tasks dyads and individuals will select strategies that differ from a preferred strategy.

(c) sixth-grade children are capable of solving relational concept attainment tasks.

(d) training, by means of informative feedback, affects performance in relational concept attainment.

The statement of the problem, review of literature, and logical assumptions were largely designed so as to arrive at testable hypotheses. They are listed below in the null[1] form.

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[1]The null hypothesis is a trial hypothesis asserting that no difference exists between two population parameters.

MAJOR HYPOTHESES:

1) There is no significant difference between the relational concept attainment of sixth-grade students, who are randomly assigned as dyads and as individuals to experimental and control groups.
2) There is no significant difference in the choices of instances, as strategies, by the dyads and individuals in these concept attainment situations.

MINOR HYPOTHESIS:

In the course of relational concept attainment there is no significant interaction between training conditions and the test conditions.

SELECTION OF SUBJECTS

The subjects were 192 sixth-grade children, drawn in equal numbers, 96 from each of two different elementary schools in the Greensboro Public School System. All of the subjects were enrolled in regular sixth-grade programs.

Each of the two schools constituted a separate unit: one was predominantly white; the other was predominantly Negro.

Consequently, all of the Negro subjects (55 girls and 41 boys) came from one school, while all of the white subjects (50 girls and 46 boys) came from a different school.

MATERIALS

The stimulus array consisted of 64 paired instances of large and small geometric figures.[2] Geometric figures were used as stimuli, because young and inexperienced students are usually better able to perceive essential relations among concepts when given some opportunity to work with concrete materials or representatives of concrete materials.[3] In addition, geometric designs represent a useful type of stimulus material for the study of relevant and irrelevant attributes, because they are readily dimensionalized in terms of values such as color, form, and border.[4]

In the design of the stimulus array, each of the 64 instances incorporated three attributes for each of the figures. All possible combinations of the attributes were included in the display. The large figures are always on the left and the small figures are always to the right of the large figures.

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[2]Bruner, op. cit., p. 42.

[3]E. Heidbreder, "Language and Concepts," Psychol. Bull., 33(1936), abstract, 724.

[4]Bourne, op. cit., p. 166.

The attributes and their alternate values are listed in Table I (p.48). The attributes were distinguished by shape, color, and border. Each attribute had two possible values or dimensions: shape (rectangle-triangle); color (black-red); border (one-none).

PROCEDURES AND STATISTICAL DESIGN

SUBJECT ASSIGNMENT USING RANDOM NUMBERS

The random numbers method was used to assign subjects to one of four treatment groups. The general purpose of randomization was to protect the internal validity of the experiment by controlling the biasing influence of extraneous variables. These variables, if not controlled in the experimental design, might produce effects confounded with the effect of the experimental stimulus. As Campbell and Stanley have indicated, "the most adequate all purpose assurance of lack of initial biases between groups is randomization."[5]

In this experiment the method of randomization was not a haphazard arrangement. It was an operational procedure that involved the use of tables of random numbers.[6]

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[5]Donald T. Campbell, and Julian C. Stanley, "Experimental and Quasi-Experimental Designs for Research on Teaching." In Handbook on Research on Teaching. Edited by N. L. Gage. (Chicago: Rand McNally & Co., 1963), p. 195.

[6]Underwood, op. cit., pp. 209-220.

TABLE I

STIMULI IN CONCEPT ATTAINMENT PROBLEMS:
THE SIX ATTRIBUTES AND THEIR VALUES

ATTRIBUTES	VALUES	
1. Shape of the large figure	rectangle	triangle
2. Color of the large figure	black	red
3. Border of the large figure. . . .	one	none
4. Shape of the small figure	rectangle	triangle
5. Color of the small figure	black	red
6. Border of the small figure. . . .	one	none

Table II (p. 50) shows the distribution of subjects (Ss) by treatment groups. One hundred ninety-two Ss participated in the pretest and in the training session. All of the Ss participated in the two posttest sessions, although some of the Ss were later randomly eliminated from the experiment for statistical purposes. Two of the treatment groups of posttest 1, Experimental (1) and Control (1), consisted of 24 dyads. Each of the other two treatment groups of posttest 1, Experimental (2) and Control (2), was composed of 24 individuals. One half of the dyadic Ss, from the Experimental (1) and Control (1) groups, served as the individual Ss in posttest 2. The other half of the groups, 24 individuals, had been randomly eliminated for statistical purposes. One-half of the Ss from the Experimental (2) and Control (2) groups, had been randomly eliminated prior to posttest 1, again for statistical purposes only. For posttest 2, the individuals were paired so that they could serve as members of dyads. Therefore, all Ss served in both posttest conditions.

If all of the Ss in the posttest conditions were counted, dyadic Ss would outnumber individual Ss, two to one. However, in the present study, a dyad worked as a unit and produced a single response to the problem instance; so the dyadic response was counted as a single response, just as if an individual and not a dyadic group had responded.

TABLE II

DISTRIBUTION OF SUBJECTS BY TREATMENT GROUPS

Groups of Ss	Ss in Each Training Group	Ss in Post-test 1 Group	Ss in Post-test 2 Group
Experimental (1)	24 Ds	24 Ds	24 Is
Experimental (2)	24 Ds	24 Is	24 Ds
Control (1)	48 Is	24 Ds	24 Is
Control (2)	48 Is	24 Is	24 Ds

NOTE: Ss= Subjects; Is= Individual Subjects; Ds= Dyadic Subjects, each member of the pair is counted.

EXPERIMENTAL PROCEDURES

Table III (p. 52) shows the design of the experiment. Experimental subjects (Es) were paired during training. Control subjects (Cs) worked as individuals during training. The Es and Cs served in dyads and as individuals during the posttests in order to eliminate any practice effects.

PRETEST

A pretest was designed (1) to assess concept attainment between schools prior to training, and (2) to be used as a training tool. However, Campbell and Stanley suggest that:

> a pretest might increase or decrease the subject's sensitivity or responsiveness to the experimental variable and thus make the results obtained for a pretested population unrepresentative of the effects of the experimental variable for the unpretested universe from which the experimental subjects were selected.[7]

Since the pretest might produce such effects, it was designed in a manner that would minimize the effects of testing on training and on the posttests.

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[7]Campbell and Stanley, op. cit., pp. 5-6.

TABLE III

DESIGN OF THE EXPERIMENT

Treatment Group	Training	Posttest 1	Posttest 2
Experimental Ss	Dyads	Dyads/Indiv	Indiv/Dyads
Control Ss	Individuals	Dyads/Indiv	Indiv/Dyads

There was only one problem presented in the pretest in order to conserve time and to reduce practice effects. It was assumed that the novelty of the single problem would serve to motivate the subjects to their best effort. If the sixth-graders were presented with more than one problem to solve, the additional problems might have depressed, rather than increased, an interest in the task.

The experimenter also concluded, from the results of pilot studies, that few subjects would be capable of reaching the criterion of six correct answers in the pretest without prior training. The pretest was an effort to assess this capability, that is, to discover whether subjects in each school would be capable of criterion performance in relational concept attainment.

It should be noted that the pretest was administered only to individual subjects. The pretest was not designed to study dyadic performance. The experimenter did not intend to relate the pretest data in any way with any of the dyadic investigations of this study. The pretest was considered to be a separate experiment and it was not correlated with the posttest. Therefore,no attempt was made to use the pretest results to adjust posttest scores.

Table IV (below) shows the pretest design. Instance number 36 served as the pretest-problem instance (see Figure 1, p. 7). One hundred ninety-two individuals, 96 from a predominantly Negro school and 96 from a predominantly white school, served as the pretest subjects. There were six correct answers to this problem.

TABLE IV

PRETEST DESIGN

Schools	Ss in Groups	Problem Instance	Correct Answers
Predominantly Negro	96 Individuals	No. 36	6
Predominantly white	96 Individuals	No. 36	6

Each subject was given a game chart, a replica of Figure 1 (p. 7). An answer sheet was also given to each of the subjects (Figure 3, p. 56). After a brief introduction by the experimenter, the subjects received the following instructions:

> Today you are going to play a game that you have never played before. It is called the Game of Differences. The only materials that you will need for the game are a game chart, a pencil, and an answer sheet. Leave the game chart and answer sheet, as they are, face down on your desks, until I tell you to turn them over. I am going to give you one problem to see how well you can play this game without ever having played it before. Now turn the game chart face up, but leave the answer sheet face down. Your first task is to find number 36 on the game chart. You should find it in the center of the chart. Your problem is now to look for 6 other numbers on your game chart that differ from number 36 in only one way. There are only 6 possible numbers that differ from number 36 in only one way. I want you to turn your answer sheet face up now. You should place one number in each of the six spaces on your answer sheet. Do not waste time because you have only one minute to find the answers. Begin now.

When one minute had elapsed, the subjects were told to stop working and to turn over their answer sheets. Es were then matched into dyadic groups, while Cs continued as individuals. The desks of the Es were placed close together to emphasize the dyadic relationship. This set the stage for the training session.

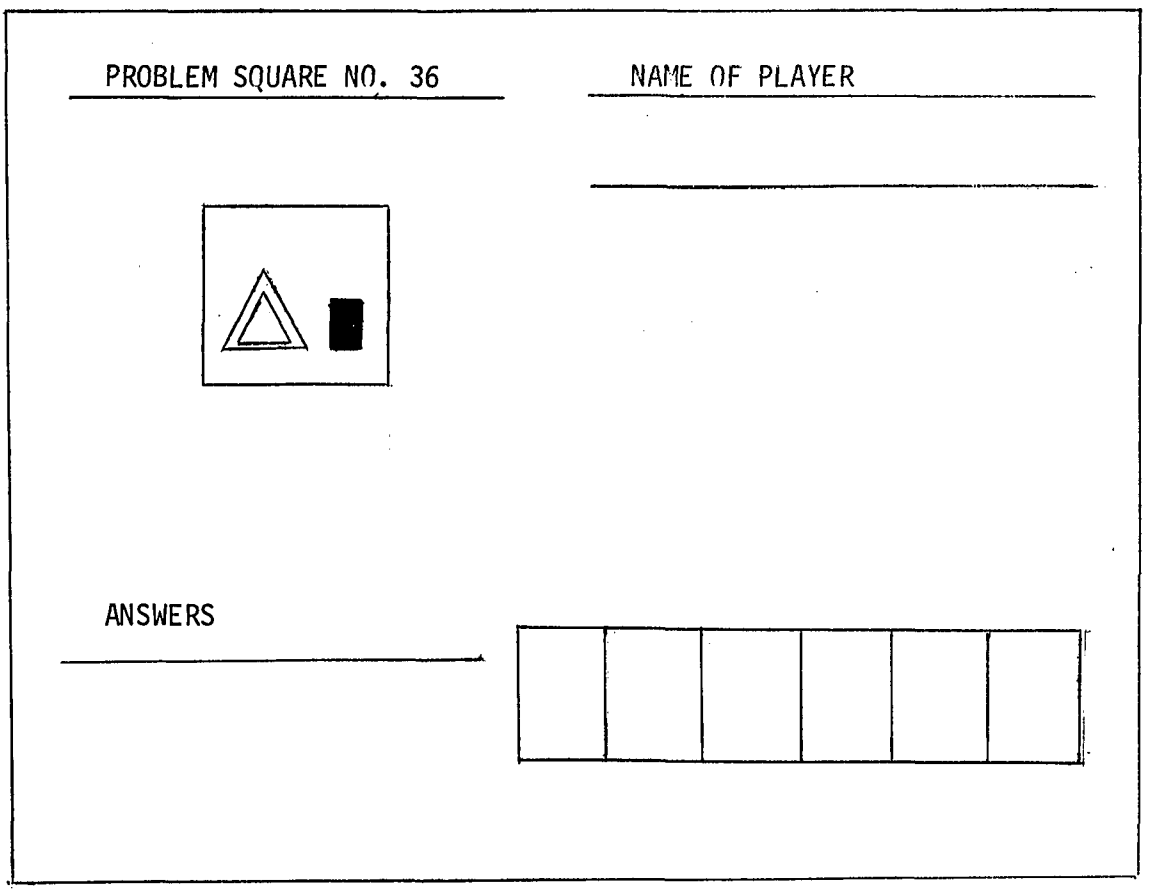

Figure 3. Special response sheet used by the subjects in the training session. Plain figure is in red, solid figure is in black.

TRAINING SESSION

The training procedures were developed to teach children a technique in problem solving. The method consisted of varying several factors in succession, while simultaneously holding one factor constant to see if there was a relationship among the factors. In addition, the training was designed to provide all of the subjects with informative feedback, that is, to provide knowledge of correct answers that could be compared to the pretest answers. Training instructions for individuals and dyads were as follows:

To the dyads:

> Those of you who are in pairs are to correct each others' answers to the first problem. I will tell you the correct answers and how to find them. Help each other make corrections.

To the individuals:

> Pass your answer sheet to the student directly behind you. I will tell you the correct answers to the first problem and how to find them.

To all of the subjects:

> Look at the small figures in the column where you find number 36. All of the small figures are the same, but the large figures in the column vary, that is, are different in either shape, color, or border. If you can locate the large figures that differ in only one way, then you have located three of the correct answers.

> Number 4 differs in color; number 44 differs in border; and the shape in number 52 is different. Write these numbers below the first three squares on your answer sheet.
>
> Look at the large figures in the row where you find number 36. All of the large figures are the same, but the small figures in the row vary in either shape, color, or border. If you can locate the small figures that differ in only one way, then you have located the rest of the correct answers.
>
> Number 34 differs in shape; number 35 differs in border; and number 40 differs in color. Write these numbers below the last three squares on your answer sheet. All of the other squares on the game chart differ from number 36 in more than one way. So they would not be answers to this problem.
>
> Now look at the answers that are in the squares and mark them as correct or incorrect. The order of answers is not important. Now put the total number of correct answers in the upper left hand corner of the answer sheet and pass it to the person in front of you.

At the end of the training session, the answer sheets were collected. Some of the subjects were reassigned to new groups for the posttest period.

POSTTEST 1

The Es and Cs were reassigned for the posttest according to the scheme of Table III (p. 53), so that two groups of dyads and two groups of individuals participated. The instructions that had been given for the pretest were repeated with the following additions for the dyads:

> Those of you who are paired are to work together in order to get the correct answers. That is, you are to talk over each possible answer to the problem until you feel that you have the correct answer.

An answer sheet that was similar in detail to Figure 3 (p. 56), but which contained a different instance from the array of Figure 1 (p. 7) was distributed. Each individual received one answer sheet while each dyad received only one answer sheet per pair. After one minute had elapsed, the answer sheets were collected. Then, answer sheets that contained a different instance from Figure 1 were distributed. These answer sheets were collected after one minute of time had elapsed.

POSTTEST 2

The Es and Cs were reassigned for posttest 2, so that the two groups of dyads participated as individuals, and the two groups of individuals worked in dyads. The instructions for posttest 1 were repeated and the subjects worked with two different instances from Figure 1.

SCORING TREATMENT

The number of correct responses was treated as the dependent variable. To simplify the analysis, and in order to examine strategies, each score represented only the correct responses. Each response was further classified according to the attribute of shape, color, or border. For each problem there were two correct answers in each of the three categories. Scores were recorded as two correct (no errors), one correct (one error), or none correct (two errors).

The resultant data appear in Tables XI, XII, and XIII of the Appendix.

Table V (p.61) lists the numbers of those instances that appeared in the posttest and were identified as problem instances. This table also lists the numbers of instances that differ by only one attribute from the problem instance. For the following descriptions to be most meaningful, it will be helpful to refer to Figure 1 (p.7). Although the following is a description of the solution to problem instance 11, the solutions for each of the other problem instances, numbers 21, 42, and 54, may be arrived at in a similar way.

The shape of one of the figures in each of instances 9 and 27 differs from the shape of one of the figures in problem instance 11. In number 9 the small figure is a triangle, while in number 11 the small figure is a rectangle. In number 27 the large figure is a rectangle while in number 11 the large figure is a triangle.

Instances 15 and 43 differ in color from instance 11. In number 15 the small figure is red, while in instance 11 the small figure is black. In number 43 the large figure is red while in instance 11 the large figure is black.

The borders in numbers 3 and 12 differ from the border in problem instance 11. In number 3 the large figure has a border, while in number 11 the large figure has no border. In number 12 the small figure has no border, while in number 11 the small figure does have a border.

TABLE V

THE SOLUTIONS TO THE PROBLEMS:

INSTANCES THAT DIFFER BY ONLY ONE ATTRIBUTE

Problem Instance	Attributes of Solution Instances		
	Shape	Color	Border
11	9 and 27	15 and 43	3 and 12
21	5 and 23	17 and 53	22 and 29
42	44 and 58	10 and 38	34 and 41
54	38 and 56	22 and 50	53 and 62

NOTE: Each solution instance includes the problem instance in all but one attribute. The solution instances are separated into categories according to the single attribute difference.

STATISTICAL DESIGN

PRETEST

The pretest was designed (1) to test a knowledge of concept attainment prior to the experimental treatments; and (2) to be used as a training tool. The data were analyzed by means of a t-test.

POSTTEST

Figure 4 (p. 63) illustrates the four-way analysis of variance design that was used in investigating the post-test results. This factorial experiment was designed to study, simultaneously, the following effects: (A) the effects of training (dyads in the experimental condition and individuals in the control condition); (B) school (Negro and white); (C) attributes in the test conditions (shape, color and border); and (D) groupings in the posttest condition (dyads and individuals). By levels, the factorial plan was a 2x2x3x2 four-way fixed model. The factors were considered fixed since the investigator, in repeating the experiment, would use the same levels of each factor.

Training Conditions (A)	School (B)	ATTRIBUTES IN TEST CONDITIONS (C)					
		SHAPE (C_1)		COLOR (C_2)		BORDER (C_3)	
		Grouping (D)		Grouping (D)		Grouping (D)	
		Dyads (D_1)	Indiv (D_2)	Dyads (D_1)	Indiv (D_2)	Dyads (D_1)	Indiv (D_2)
EXPERIMENTAL (A_1)	NEGRO (B_1)						
	WHITE (B_2)						
CONTROL (A_2)	NEGRO (B_1)						
	WHITE (B_2)						

Figure 4. Experimental design for the four-way analysis of variance of posttest results - 2x2x3x2 factorial plan.

In the mathematical development of the analysis of variance, a number of assumptions were made:

1. Distribution of the variables in the population, from which the samples were drawn, was normal.

2. Variances in the population, from which the samples were drawn, were equal (homogeneous variances).

3. Effects of the various factors on the total variation was additive.

4. Members were randomly assigned to treatments.

The subjects in the test conditions were nested.[8] This meant that dyads and individuals were exposed to either one, but not to both, of the training conditions. This situation was considered in the experimental treatment. The experiment was designed so that individual differences could be statistically controlled in all of the more important comparisons.

The analysis of variance design included a partitioning of the sum of squares into a number of components, some of which were based upon between-subjects comparisons and others upon within-subjects comparisons. The experimental

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[8] Campbell, and Stanley, op. cit., pp. 29-31. This effect is also described as a "mixed" design in E. F. Lindquist, Design and Analysis of Experiments in Psychology and Education, (Boston: McGraw-Hill Book Company, 1956). pp. 266-267.

group (A_1) entered into all combinations of B, C, and D: $A_1\ B_1\ C_1\ D_1$, $A_1\ B_1\ C_1\ D_2$, $A_1\ B_1\ C_2\ D_1$ . . . $A_1\ B_2\ C_3\ D_2$. The second group, the control group (A_2) entered into all combinations of B, C, and D as $A_2\ B_1\ C_1\ D_1$, $A_2\ B_1\ C_1\ D_2$ . . . $A_2\ B_2\ C_3\ D_2$.

The total experiment may thus be regarded as consisting of four treatments X subjects experiments, one with A held constant at the A_1 level and another with A held constant at the A_2 level. The A effect was a within-subjects effect, while the B, C, and D effects were between-subjects effects. This method of partitioning the error components in the analysis of variance allowed for the effects of individual differences to be held constant and not merely randomized.[9] Consequently, the overall statistical results should be more precise, since the two error terms were considered separately and not compounded.

Confidence Levels of Main and Interaction Effects

The major purpose of the present study was to determine the main treatment effects, that is, whether the treatments would have the same average effects at all levels. A

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[9]Lindquist, op. cit., pp. 281-297.

second purpose of the experiment was to determine the interaction effects, that is, whether there is any interaction of treatments and levels.

Since the present experiment was of an exploratory nature, it was necessary to set a relatively high level of significance for F tests of the null hypotheses main effects. For a null hypothesis to be rejected, the F-ratio for main effects had to meet or exceed the .05 level of confidence.

On the other hand, Bancroft has recommended a test of significance of interaction at the .25 probability level if the main effect tests are to made at the .05 level.[10] Such a step was particularly desirable because there should be an increase in the confidence in main effects if the interaction should not be significant. Consequently, the less rigorous confidence level for interaction was adopted. The F-test for interaction effects had only to meet or exceed the .25 probability level for the minor null hypothesis to be rejected.

However, the selection of a less rigorous confidence level increases the chance of committing a Type I error. That is, when reaching a decision about the null hypothesis,

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[10]T. A. Bancroft, Topics in Intermediate Statistical Methods (Ames, Iowa: The Iowa State University Press, 1968), p. 9.

an alternative hypothesis may be accepted when the null hypothesis is true. Still, it appeared reasonable to take the risk and adopt the .25 probability level rather than to risk making a Type II error, which would mean accepting the null hypothesis when it was really false. A Type II error could lead one to assume that interaction was not present and overestimate the significance of main effects. The decision to risk the Type I error, rather than the Type II error, was based on a preference to underestimate rather than to overestimate the significance of main effects.

When main effects were found to be significant, a posteriori comparisons could be made according to the Scheffé design.[11] The criterion of this method is that the probability of rejecting the null hypothesis, when it is true, should not exceed .10 for any of the orthogonal, that is, independent, comparisons of pairs of means. Since the Scheffé method is more rigorous than some other multiple comparison methods, with regard to Type I errors, it may lead to fewer significant differences among means. Therefore, Scheffé has recommended that the less rigorous

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[11]Henry Scheffé, "A Method for Judging All Contrasts in the Analysis of Variance," Biometrika, 40, 1953. p. 87-104.

significance level of .10 may be used with no accompanying loss of statistical power.[12] Accordingly, the .10 level of significance for orthogonal comparisons was adopted for use in this study.

SUMMARY

This chapter described the major and minor hypotheses, the procedures for subject selection and randomization, the materials used in the problem, the statistical design for the treatment of experimental results and a full explanation of the experimental procedures. In Chapter IV, "Treatment of Results," the statistical analyses are performed.

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[12] Henry Scheffé, Analysis of Variance (New York: John Wiley and Sons, Inc., 1959).

CHAPTER IV

TREATMENT OF RESULTS

PRETEST RESULTS

The statistics of Table VI (below) were calculated from the pretest data. ΣXs are the sum of the raw scores. The $\overline{X}$s are sample means based upon the scores of 192 subjects. Table XIV of the Appendix displays the raw scores for the pretest problem. The unbiased estimate of variance was 1.00. The t-ratio, $t = 6.86$, was significant: $P < .01$. A significant difference between the two group means was indicated. The mean of the predominantly white school exceeded the mean of the predominantly Negro school.

TABLE VI

PRETEST

RESULTS BY SCHOOL

	SCHOOL	
	Predominantly Negro	Predominantly White
N	96	96
ΣXs	87	180
$\overline{X}$s	0.91	1.87
ΣX^2s	189	455

NOTE: The pretest was administered to individuals only.

POSTTEST RESULTS

Subjects were given four relational-concept problems to solve; only the correct responses were recorded. Before these data were analyzed, the correct responses were blocked into tabular form (Tables XI, XII, XIII of the Appendix).

MAIN EFFECTS

Analyses of variance were computed for the posttest results. A summary of the 2x2x3x2 factorial design is presented in Table VII (p. 71). The design required the use of a table of F-ratios with 1 degree of freedom for the greater mean square, and with 180 degrees of freedom for the lesser mean square. The following values of the F-ratios were required for significance at the .01, .05, and .25 levels of confidence: $F_{.01}=6.81$; $F_{.05}=3.91$; $F_{.25}=1.32$.

The main effects of (A) training conditions; (B) of school; (C) of test conditions; and (D) of group size were all statistically significant: $P<.01$ for B and C and $P<.05$ for A and D.

TABLE VII

ANALYSIS OF VARIANCE
MAIN AND INTERACTION EFFECTS

Source	Sum of Squares	degrees of freedom	Mean Square	F ratio	P level
Between-Subjects	368.74	191			
B (School)	37.49	1	37.49	36.75	<.01
C (Attributes)	132.10	2	66.05	64.75	<.01
D (Group Size)	6.51	1	6.51	6.38	<.05
B X C	0.20	2	0.10	<1.00	>.25
B X D	1.05	1	1.05	1.02	>.25
C X D	5.20	2	2.60	2.55	<.25
B X C X D	2.88	2	1.44	1.41	<.25
Within (b)	183.31	180	1.02		
Within-Subjects	344.00	192			
A (Training)	7.05	1	7.05	3.85	<.05
A X B	1.25	1	1.25	<1.00	>.25
A X C	0.83	2	0.47	<1.00	>.25
A X D	0.53	1	0.53	<1.00	>.25
A X B X C	0.85	2	0.43	<1.00	>.25
A X B X D	0.60	1	0.60	<1.00	>.25
A X C X D	3.01	2	1.51	<1.00	>.25
A X B X C X D	3.94	2	1.97	1.08	>.25
Within (w)	328.95	180	1.83		
Total	712.74	383			

Figure 5 (p. 73) shows that the higher Mean Correct Responses (MCR) in the experimental training condition (A_1) were correlated with school (B_2). The subjects from school (B_2, predominantly white) in A_1 and A_2 conditions had MCR of 1.26 and 1.13, respectively, while the subjects from school (B_1, predominantly Negro) in the A_1 and A_2 conditions had MCR of 1.01 and 0.96, respectively.

Figure 6 (p. 74) shows the MCR for attributes in test conditions (shape, color, border) correlated with the MCR group size (dyad or individuals). The MCR of shape (C_1), for dyads (D_1), and individuals (D_2), were 1.02 and 1.05, respectively. For color (C_2) the MCR were 0.94 and 0.84, respectively. The MCR for border (C_3) were 1.44 and 1.27, respectively. Clearly, there is a directional effect in operation. In descending order: the greater MCR for border are followed by MCR of shape and the MCR of color. The same directional effect is operating in each separate panel of D values.

Figure 7 (p. 75) illustrates a higher MCR of the dyads (D_1) in the test condition correlated with the experimental condition (A_1). Dyadic subjects had MCR of 1.15 and 1.12 respectively, while individual subjects had MCR of 1.12 and 0.98, respectively.

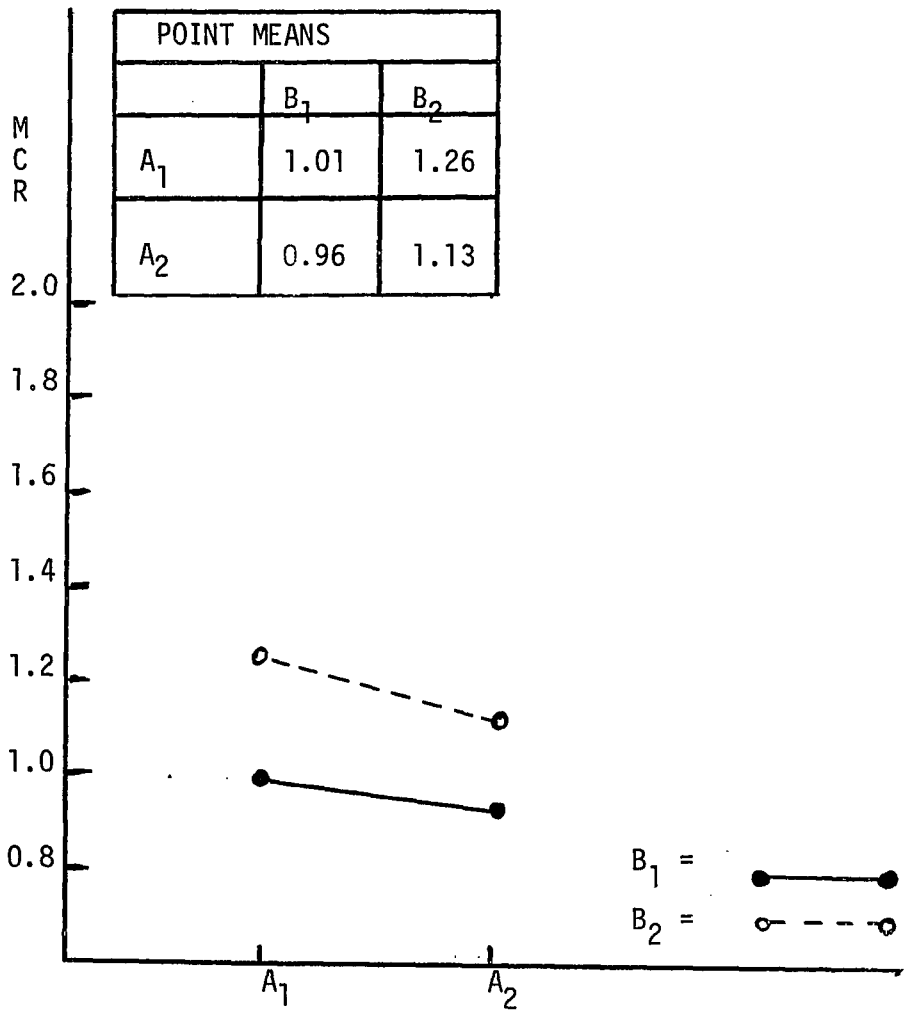

Figure 5. Main Effect of Training Conditions and School. A_1 = Experimental, A_2 = Control. B_1 = Negro, B_2 = White. MCR = Mean Correct Responses.

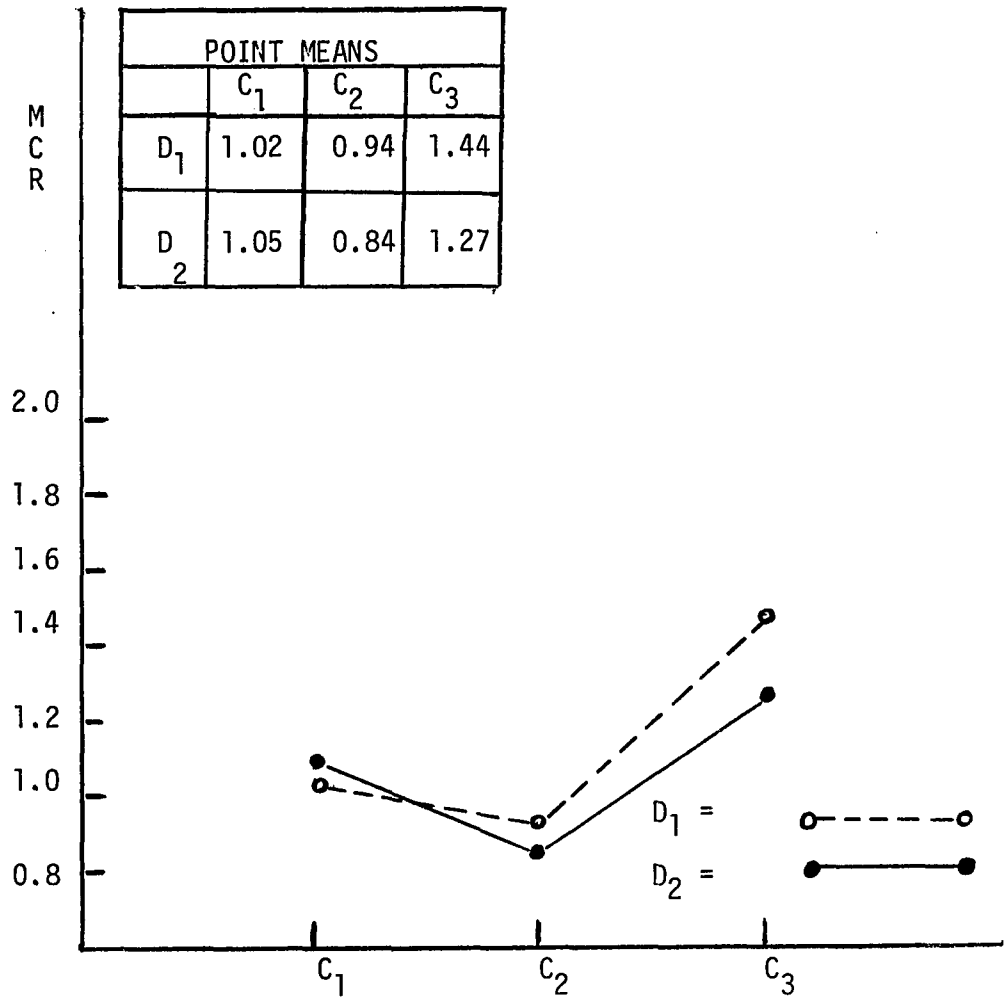

Figure 6. Main Effect of Attributes and Group Size in Test Condtions. C_1 = Shape, C_2 = Color, C_3 = Border. D_1 = Dyads, D_2 = Individuals. MCR = Mean Correct Responses.

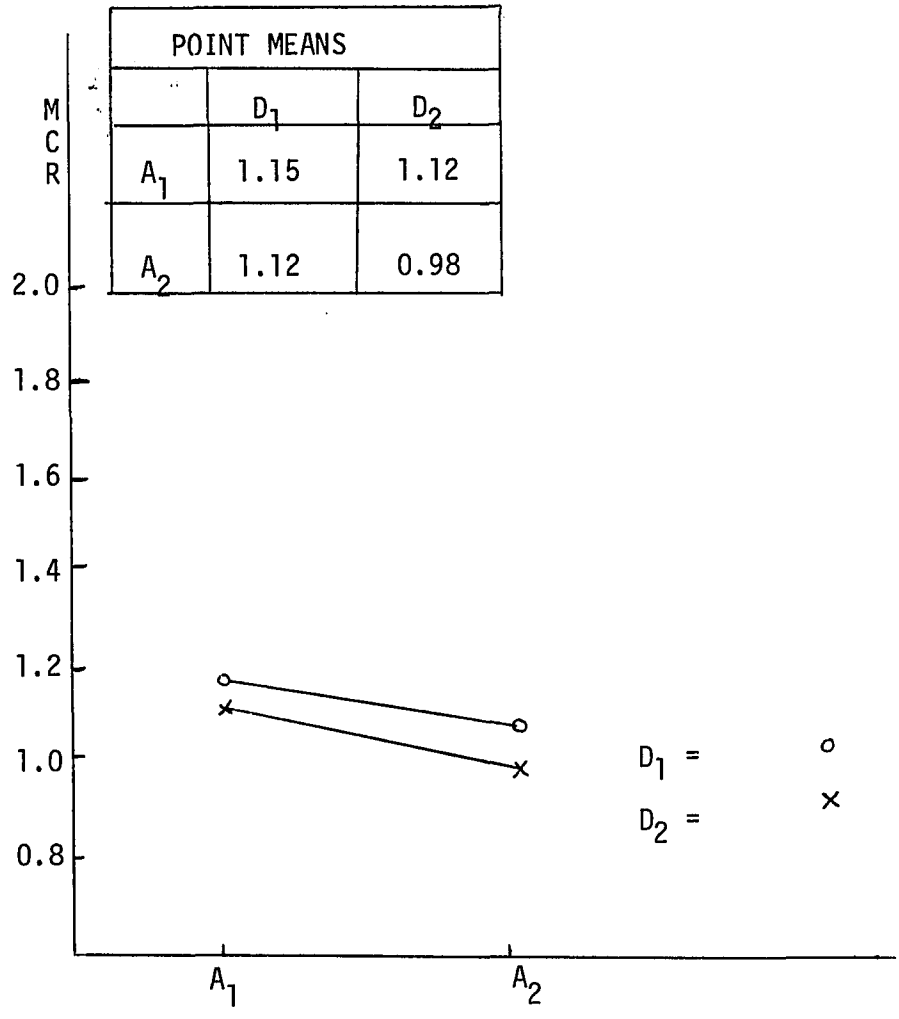

Figure 7. Main Effect of Training Condition and Test Condition. A_1 = Experimental, A_2 = Control. D_1 = Dyads, D_2 = Individuals. MCR = Mean Correct Responses.

Figure 8 (p. 77) shows the effects of training conditions and attributes in the test conditions. The MCR of the experimental condition (A_1) were 1.09 for shape (C_1); 0.92 for color (C_2); and 1.41 for border (C_3). The MCR for the control condition (A_2) were 0.97 for shape; 0.87 for color; and 1.31 for border. C had the same directional effect for each separate panel of A values.

INTERACTION EFFECTS

The interaction effects in the test condition of the attributes (C) X group size (D) were significant beyond the .25 level of confidence. In Figure 6 (p. 74), it may be seen, an interaction of D values occurs at the C_2 level. Although C and D showed main directional effects, the individual MCR for the attribute differences in color were lower than the dyadic MCR for color; this interaction limits the extent to which the main effects may be generalized.

Schools (B) X attribute (C) X group size (D) interaction was significant beyond the .25 level of confidence. Figure 9 (p. 78) shows the interaction of the three factors in two dimensions. The interaction of MCR is evidenced at C_1 by B_2 D_1 and B_2 D_2, and at C_2 by B_2 D_1 and B_2 D_2. Directional effects of B, C, and D were noticed at all other levels; a correlation of the MCR of the dyads, of the predominantly white school, and of the attribute of shape, was also noted. The specificity of these effects is discussed in Chapter V.

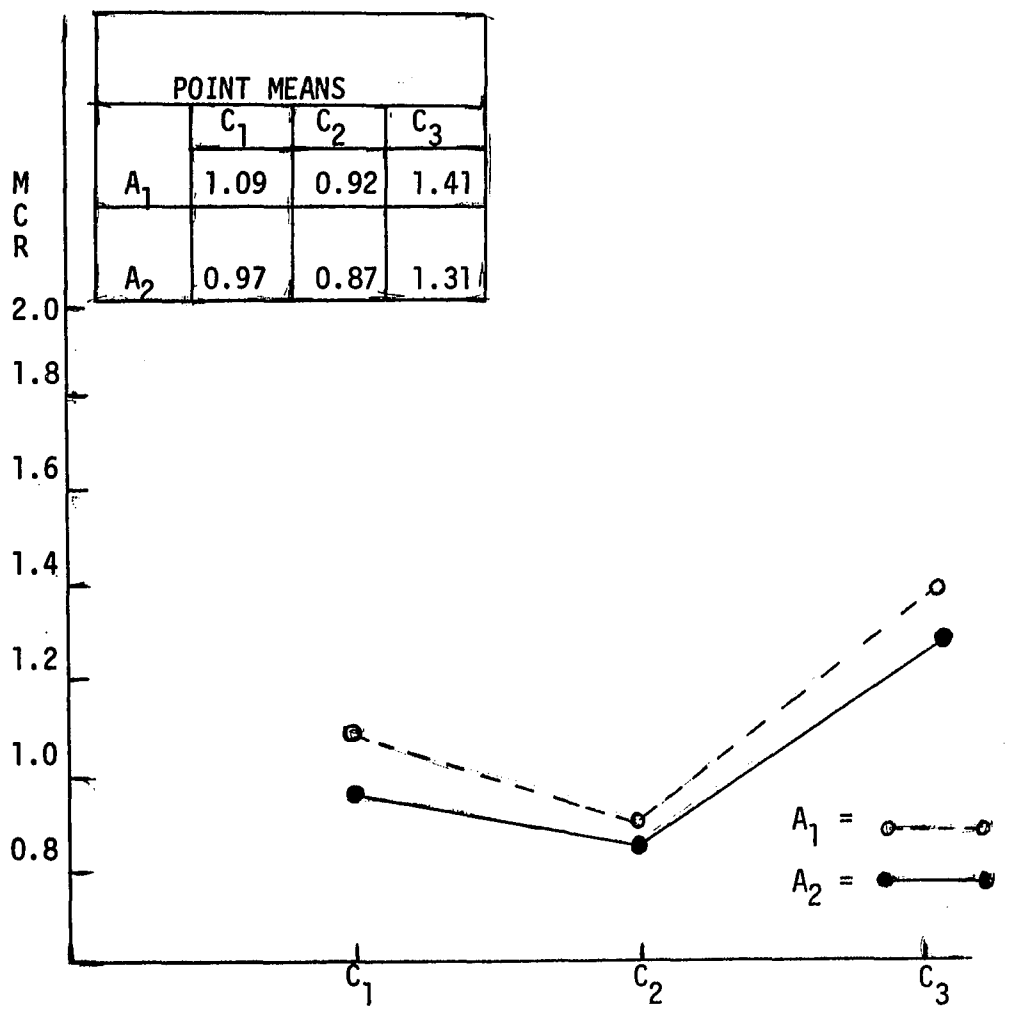

Figure 8. Main Effects of Training Conditions and Attributes. A_1 = Experimental, A_2 = Control. C_1 = Shape, C_2 = Color, C_3 = Border. MCR = Mean Correct Responses.

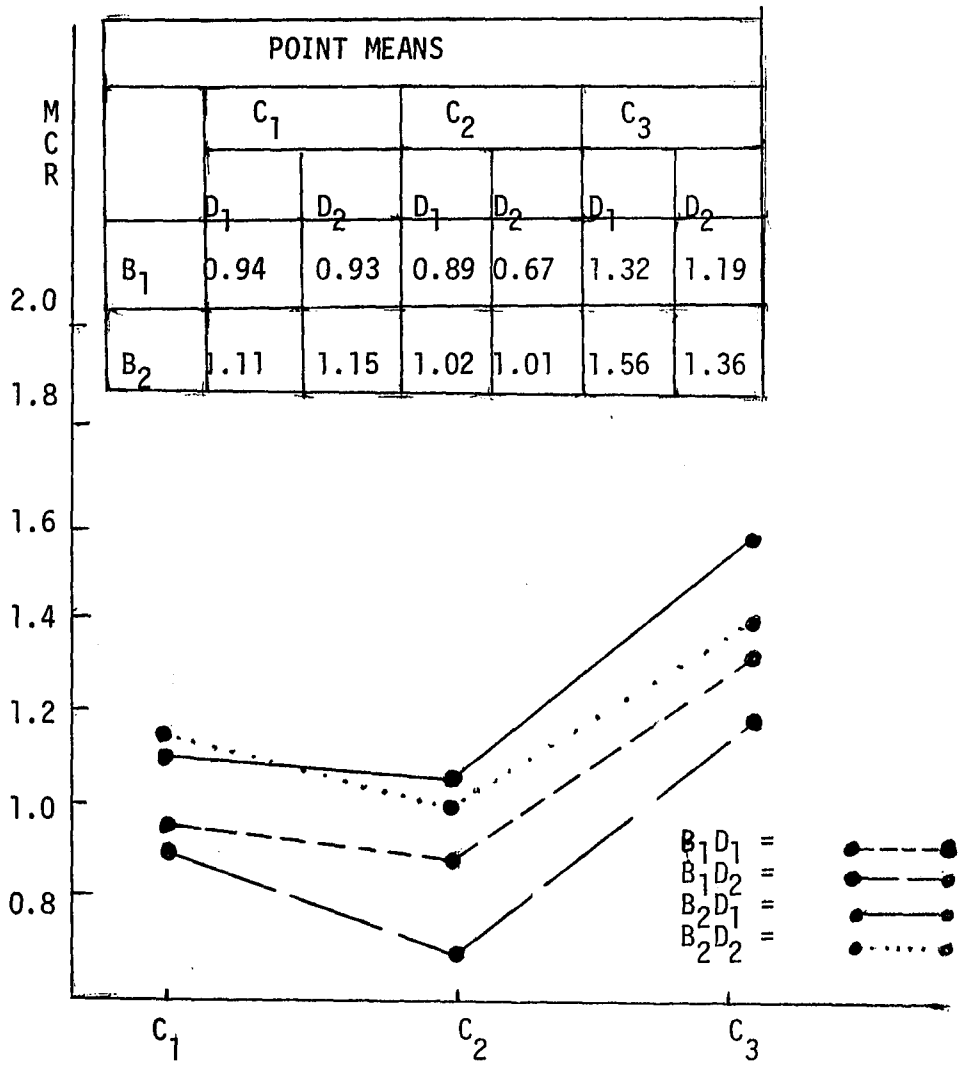

Figure 9. Attributes x School x Group Size Interaction. C_1 = Shape, C_2 = Color, C_3 = Border. B_1 = Predominantly Negro, B_2 = Predominantly White. D_1 = Dyads, D_2 = Individuals. MCR = Mean Correct Responses.

ORTHOGONAL COMPARISONS

In Table VIII (p. 80) the MCR of training conditions (A) were compared with the MCR of the attributes in test conditions (C). The following comparisons achieved significance when the observed F-ratios equaled or exceeded the criterion of the more rigorous F-ratio ($F'_{.10}=5.42$)[1]:

A_1C_2X A_1C_3- In the experimental condition border exceeds color.

A_2C_2 X A_1C_3- In the control condition border exceeds color.

In Table IX (p.81) the MCR of schools (B) were compared with the MCR of the attributes (C). The following comparisons achieved significance when the criterion of the more rigorous F-ratio ($F'_{.10}=5.42$) was applied:

B_1C_2 X B_2C_3- Border by school (B_2) exceeded color by school (B_1).

B_2C_2 X B_2C_3- For school (B_2), border exceeded color.

B_1C_1 X B_2C_3- Border by school (B_2) exceeded shape by school (B_1).

B_1C_3 X B_2C_3- School (B_1) was exceeded in border by school (B_2).

B_2C_1 X B_2C_3- For school (B_2), border exceeded shape.

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[1]F' is a quantity which is twice the F required at the desired level. For any difference to be significant at the required level, F must be greater than or equal to F'.

TABLE VIII

ORTHOGONAL COMPARISONS OF MEAN CORRECT RESPONSES FOR TRAINING CONDITIONS (A) X ATTRIBUTES (C)

POINT MEANS

	C_1	C_2	C_3
A_1	I 1.09	II 0.92	III 1.41
A_2	IV 0.97	V 0.87	VI 1.31

A_1=Experimental; A_2=Control

C_1=Shape; C_2=Color; C_3=Border

COMPARISON	F	*P <.10
I, II	<1.00	
I, III	2.69	
I, IV	<1.00	
II, III	6.32	*
II, V	<1.00	
III, V	7.67	*
III, VI	<1.00	
IV, V	<1.00	
IV, VI	3.02	
V, VI	5.09	

$F'_{.10}$=5.42 for a significant F-ratio

TABLE IX

ORTHOGONAL COMPARISONS OF MEAN CORRECT RESPONSES
SCHOOLS (B) X ATTRIBUTES (C)

POINT MEANS

	C_1	C_2	C_3
	I	II	III
B_1	0.97	0.78	1.04
	IV	V	VI
B_2	1.13	1.01	1.63

B_1=Predominantly Negro

B_2=Predominantly White

C_1=Shape; C_2=Color; C_3=Border

COMPARISON	F	*P <.10
I, II	1.72	
I, III	< 1.00	
I, IV	1.21	
I, VI	20.75	*
II, III	3.22	
II, V	2.52	
II, VI	34.40	*
III, VI	16.58	*
IV, V	< 1.00	
IV, VI	11.90	*
V, VI	18.30	*

$F'_{.10}$=5.42 for a significant F-ratio

In Table X(below) the MCR of group size (D) were compared with the MCR of the attributes (C). The following comparisons achieved significance when the Scheffé F-ratio ($F'_{.10}=5.42$) was applied:

D_1C_2 X D_1C_3- For dyads, border exceeded color.

D_1C_1 X D_1C_3- For dyads, border exceeded shape.

D_2C_2 X D_2C_3- For individuals, border exceeded color.

D_1C_2 X D_2C_3- Shape by individuals was exceeded by border of dyads.

D_1C_3 X D_2C_3- Color by individuals was exceeded by border of dyads.

TABLE X

ORTHOGONAL COMPARISONS OF MEAN CORRECT RESPONSES
GROUP SIZE (D) X ATTRIBUTES (C)

POINT MEANS

	C_1	C_2	C_3
D_1	I 1.02	II 0.94	III 1.44
D_2	IV 1.05	V 0.84	VI 1.27

D_1=Dyads; D_2=Individuals

C_1=Shape; C_2=Color; C_3=Border

COMPARISON	F	*P<.10
I, II	<1.00	
I, III	8.40	*
I, IV	<1.00	
II, III	11.90	*
II, V	<1.00	
III, IV	7.25	*
III, V	17.50	*
III, VI	1.38	
IV, V	2.10	
IV, VI	2.36	
V, VI	8.80	*

$F'_{.10}=5.42$ for a significant F-ratio

SUMMARY

In this chapter data relevant to each hypothesis were assembled in quantitative form. These data were then tested to determine whether there were significant differences in the results. All main and interaction effects were tested. The special Scheffé method was applied to orthogonal comparisons of cell means. In Chapter V, "Findings, Conclusions, and Recommendations," the findings of the study are listed, together with conclusions drawn from the findings and recommendations for future research.

CHAPTER V

FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

SUMMARY

The purposes of this study were (1) to determine whether children attain relational concepts as efficiently when they work as individuals as when they work in dyads; and (2) to compare, as strategies, the choices of dyads and individuals in the concept attainment experiments.

A special instrument was designed to test relational concept attainment. This device was a stimulus array that consisted of 64 instances in which large and small geometric figures were paired (Figure 1, p. 7).

The subjects were 192 sixth-grade children, drawn in equal numbers, 96 from each of two elementary schools in the Greensboro, North Carolina Public School System. One school was predominantly white, while the other school was predominantly Negro.

Subjects were required to find in the stimulus array, all of the instances that differed in only one attribute from a problem instance. This task amounted to a demonstration of the knowledge of a concept rather than simply to the

discovery of a concept. The task involved finding relationships between several concepts at several different levels before the criterion of the concept attainment task could be reached. Data were obtained to test null hypotheses regarding main and interaction effects. An analysis of variance was used to determine relationships within a four-way factorial design.

FINDINGS

MAJOR HYPOTHESES

Hypothesis 1 predicted no significant difference between the relational concept attainment performances of sixth-grade students randomly assigned as dyads and as individuals to experimental and control groups. The data, as given in Table VII (p. 71), indicate that a significant superiority in relational concept attainment posttest is shown by the dyads when compared to the individuals. Furthermore, those subjects who were trained as dyads performed significantly better than those subjects who were trained as individuals. The dyads from the predominantly Negro school (B_1) were superior performers when compared with the individuals from that school. The dyads from the predominantly white school (B_2) were superior performers when compared with the individuals from that school. Further, dyads from the predominantly

white school performed significantly better than the dyads from the predominantly Negro school. As a result of the significant F-ratios, null hypothesis 1 (p. 45) is rejected, instead the following logical assumptions (b,e) are suggested:

1. Dyads will outperform individuals in relational concept attainment.

2. Training, by means of informative feedback, affects the performance of the dyads and individuals in the concept tasks.

Hypothesis 2 predicted no significant differences in the choices of instances, as strategies, by the dyads and individuals in the relational concept attainment situations. The data from Tables VIII (p. 80), IX (p. 81), and X (p. 82), clearly show a significant difference between the MCR for the attributes selected. A complete description of the directional effects was given in Figures 6(p. 74), 8 (p. 77), and 9 (p. 78). A preferred strategy, suggested by studies of Bruner[1] and Heidbreder,[2] predicted the following preferred order in which the greater numbers of correct responses would

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[1]Bruner, Goodnow, and Austin, op. cit., p. 55.

[2]Heidbreder, Bensley, and Ivy, op. cit., p. 299-300.

be selected: (1) shape, (2) color, and (3) border. The data from this study show that the order of selection, by dyads and individuals, in either experimental or control conditions, does not correspond to the preferred strategy. Instead, the findings indicate a different directional effect. The instances that differed in border were correctly selected most often; differences in shape were selected second; instances that differed in color were selected correctly the fewest times. There are clear indications, after an examination of the orthogonal comparisons of the MCR, that the directional effects are generalized across training conditions and test conditions. After training as dyads, subjects from both the predominantly Negro school and the predominantly white school showed the same directional effects on MCR: border was selected correctly most often, shape was next, and color was correctly selected least often. The MCR, of the subjects who were trained as individuals, showed the same directional effects. On the strength of the significant F-ratios, null hypothesis 2 (p. 45) is rejected. The logical assumption (c) is suggested: Dyads and individuals will select strategies in relational concept attainment tasks that do not conform to a preferred strategy.

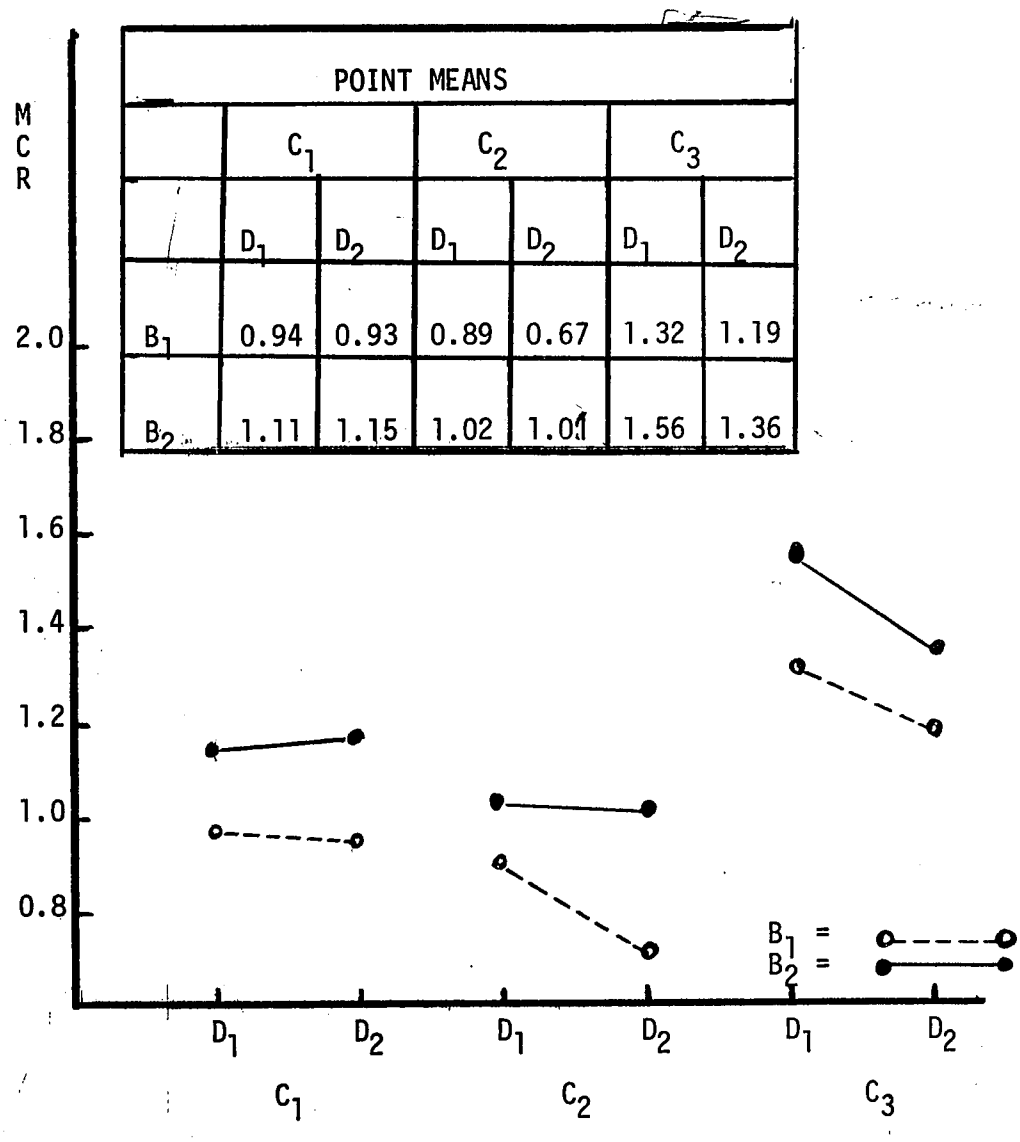
MINOR HYPOTHESIS

The minor hypothesis was a prediction of simple effects: there would be no significant interaction between the training conditions A, B and the test conditions C, D. It was noted earlier (p.66), that the F-test for interaction effects had only to meet or exceed the .25 probability level for the minor hypothesis to be rejected. The data, as given in Table VII (p.71), revealed that there were statistically significant interaction effects ($P<.25$).

Two of a possible eleven interactions were statistically significant at the .25 level of confidence. Because two significant interactions were discovered, the associated main effects may not be generalized with confidence. It should be noted, however, that nine interactions were not statistically significant. This would seem to indicate that interaction was not an important limiting factor in all aspects of this study.

One statistically significant interaction ($P<.25$) occurred between the test conditions: attributes (C) X group size (D). Figure 6 (p.74) showed that the MCR of D_2C_2 was slightly more depressed than D_1C_2. However, the directional effects for D and C do not appear to be disturbed by the interaction. The explicit main effects for C and D, which showed significant differences at $P<.05$, nonetheless, cannot be generalized and must reflect the interaction of C X D.

The second statistically significant interaction occurred between schools, attributes, and group size (B X C X D). Figure 9 (p. 78) illustrated consistant directional effects among all of the factors. The interaction occurred at C_1 by B_2 D_1 and B_2 D_2, and at C_2 by B_2 D_1 and B_2 D_2. Figure 10 (p. 90) shows the three factor interaction. It is apparent that there is no interaction in C_3, while interactions are occurring at C_1 and C_2. At C_2 the directional effects are similar to previous directional effects. At C_1, however, the MCR of subjects from the predominantly white school have increased and thus depart from the systematic directional effects of the other MCR. From this result it may be suggested that the dyads from the predominantly white school were more resistant to training than were individuals from that school, or that the attribute of shape was a less predictable factor in the study.



	C_1		C_2		C_3	
	D_1	D_2	D_1	D_2	D_1	D_2
B_1	0.94	0.93	0.89	0.67	1.32	1.19
B_2	1.11	1.15	1.02	1.01	1.56	1.36

Figure 10. Interaction Effects of Three Factors. Schools x Attributes x Group Size. B_1 = Predominantly Negro, B_2 = Predominantly White; C_1 = Shape, C_2 = Color, C_3 = Border. D_1 = Dyads, D_2 = Individuals. MCR = Mean Correct Responses.

CONCLUSIONS

The results of this experimental study prompt the investigator to draw the following conclusions:

1. Dyadic training is a factor that accounts for superior performance in relational concept attainment. To generalize on a wide basis concerning this fact is not possible. It seems, however, that teachers would find their students gaining a greater measure of success in concept attainment if the students were sometimes paired during the learning process.

2. Dyads outperform individuals in relational concept attainment, regardless of training procedures. This investigation has pointed out that when dyads qua dyads are tested, performance is superior to that of individuals. Too often, research is designed to determine whether skills learned in groups will transfer to individuals, to the neglect of testing the group skills qua group skills. An alternative to individual teaching and learning is suggested: dyadic teaching and learning.

3. This investigation extended the definition of relational concept attainment to include relations among concepts rather than simply among attributes. Consequently, it would be imprudent to generalize the findings that deal with observed strategies. Nonetheless, it would appear to be worthwhile for teachers to experiment with strategies in the classroom by utilizing the two findings from this study: (1) the observed strategies of dyads and individuals differed from a preferred strategy in relational concept attainment; and (2) there was a directional effect to the attribute selection.

4. The results of the pretest showed that subjects from the predominantly Negro school did not perform as well as the subjects from the predominantly white school. However, the posttest scores show that the gap between the two schools narrowed after training.

5. It has been shown that dyadic experiments can be conducted in school settings. In addition, an instrument that was devised to test concept attainment was demonstrated to have practical value in dyadic experiments.

In summary, these outcomes have important implications for classroom teachers, as they attempt to arrange learning conditions under which concept attainment may occur. The results provide teachers with a dyadic alternative: a pairing of individual students into dyads, to offset the growing power of mass information and technology which seems to threaten the integrity of individual students.

RECOMMENDATIONS

The results of this investigation should be of interest to educators responsible for curriculum change, to psychologists responsible for research in cognitive studies of children, and to sociologists concerned with research designs and investigations concerning the dyad. It is recognized, however, that further studies of the dyad and concept attainment are needed. It is suggested that the geometrical array that was devised for this study be employed in future research. The fact that it can be used for both individuals and dyads and with large numbers of children makes it a practical instrument for use in most classroom situations.

In addition to the above, the following studies are recommended for future research:

1. A study of the best ways to couple individual children into dyadic teams based upon special skills, intellectual potential, social qualities, differences in I.Q., and age and sex differences.

2. A study in which elapsed time may be considered as a function of concept attainment; that is, to test concept attainment at different intervals of time until the criterion performance is reached.

3. A study in which dyads from integrated schools as well as all white or all Negro schools are tested on a range of cognitive tasks.

4. A study in which I.Q. scores would be a relevant variable in relational concept attainment among dyads.

5. A study which considers differences between boys and girls in strategy preference.

6. A study to determine whether there is a definite order for the location of attributes - - an order coincident with the order revealed by Heidbreder's research.

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APPENDIX:

TABLE XI

POSTTEST RAW SCORES FOR INDIVIDUALS AND DYADS*
CLASSIFIED ACCORDING TO SHAPE

Training Condition (A)	School (B)	TEST CONDITION (C) SHAPE (C_1) GROUPING (D) DYADS	INDIVIDUALS
EXPERIMENTAL (A_1)	NEGRO (B_1)	2 2 1 1 0 0 1 1 1 2 1 0 1 1 0 1 1 0 1 1 0 1 1 1 1 1 0 1 1 1 2 1 0 1 0 0 2 0 0 1 1 0 1 1 0 1 0 0	2 1 0 2 0 0 1 1 0 2 0 0 2 1 1 2 0 0 1 1 0 1 1 0 1 1 0 1 1 1 0 0 0 1 1 1 2 2 0 1 1 0 2 1 1 1 1 0
	WHITE (B_2)	2 1 0 2 1 1 2 1 1 2 1 0 2 2 1 2 1 0 2 1 0 1 1 1 2 1 0 2 1 1 2 2 1 1 1 0 2 1 0 2 1 1 2 2 0 2 1 1	2 1 1 2 1 1 2 1 1 1 1 1 2 2 1 2 2 0 2 1 1 2 2 1 2 1 1 2 2 0 2 2 0 2 1 1 2 2 0 1 1 0 2 1 0 2 2 1
CONTROL (A_2)	NEGRO (B_1)	2 1 1 2 2 1 1 0 0 1 1 0 1 1 0 2 1 1 2 1 0 1 1 0 1 1 1 1 1 0 1 1 1 2 1 1 1 1 1 2 1 1 2 0 0 2 0 0	1 1 0 2 1 0 1 1 0 1 1 0 2 1 1 1 1 0 1 1 1 2 1 0 2 1 0 0 0 0 1 1 1 1 0 0 2 1 1 1 1 1 1 1 0 2 1 1
	WHITE (B_2)	1 1 0 2 0 0 2 1 1 2 2 1 2 2 0 2 2 1 2 1 1 2 1 1 2 0 0 2 1 0 2 1 0 1 1 1 1 1 0 2 0 0 2 1 0 2 2 0	2 0 0 2 1 0 1 0 0 2 0 0 2 2 1 2 1 0 2 1 1 2 1 1 2 2 0 2 0 0 1 1 0 1 1 0 2 0 0 2 1 1 1 1 1 2 2 0

*For a description of the scoring treatment, see p. 59

TABLE XII

POSTTEST RAW SCORES FOR INDIVIDUALS AND DYADS *
CLASSIFIED ACCORDING TO COLOR

Training Condition (A)	School (B)	TEST CONDITION (C) COLOR (C_2) GROUPING (D) DYADS	TEST CONDITION (C) COLOR (C_2) GROUPING (D) INDIVIDUALS
EXPERIMENTAL (A_1)	NEGRO (B_1)	2 1 0 2 2 2 2 2 0 1 1 0 2 1 1 1 1 0 1 1 1 2 0 0 2 2 1 0 0 0 2 1 1 1 1 1 2 1 0 0 0 0 2 1 1 2 1 0	2 0 0 2 1 1 2 1 1 1 1 0 0 0 0 2 1 0 2 0 0 2 2 1 2 0 0 1 1 1 2 1 0 2 0 0 1 1 0 1 1 0 1 0 0 2 2 0
	WHITE (B_2)	1 1 0 1 1 0 2 0 0 1 1 1 2 1 0 1 1 0 1 1 1 1 0 0 2 2 0 2 2 1 2 2 1 1 1 0 1 1 0 1 1 0 2 2 1 2 2 2	2 2 0 1 0 0 2 2 1 1 0 0 2 1 1 1 1 1 2 1 1 1 1 0 1 1 0 2 2 2 2 2 1 2 1 1 2 2 0 2 1 1 1 1 1 1 1 0
CONTROL (A_2)	NEGRO (B_1)	2 2 1 2 2 1 2 2 1 2 1 1 2 0 0 2 1 0 1 1 0 2 0 0 1 1 0 2 1 0 2 1 0 1 1 0 2 0 0 0 0 0 1 1 0 1 1 0	1 1 1 2 1 0 2 0 0 1 1 0 1 0 0 2 1 0 2 0 0 1 0 0 2 0 0 2 1 0 1 1 1 1 0 0 1 0 0 1 0 0 1 1 0 1 1 0
	WHITE (B_2)	1 1 1 2 1 0 2 1 1 1 1 0 2 1 0 1 1 0 2 2 0 1 1 1 2 1 0 2 1 0 2 1 1 2 1 0 0 0 0 1 1 0 2 2 0 2 1 1	2 0 0 1 1 0 2 1 1 2 2 0 2 1 0 1 1 0 2 1 0 1 1 1 0 0 0 2 1 1 1 1 0 2 2 1 1 1 0 2 1 1 1 1 1 1 1 0

*For a description of the scoring treatment, see p. 59

TABLE XIII

POSTTEST RAW SCORES FOR INDIVIDUALS AND DYADS*
CLASSIFIED ACCORDING TO BORDER

Training Condition (A)	School (B)	TEST CONDITION (C) BORDER (C_3) GROUPING (D) DYADS	INDIVIDUALS
EXPERIMENTAL (A_1)	NEGRO (B_1)	2 2 0 2 2 2 2 2 1 2 2 1 2 1 0 2 2 1 2 2 1 2 1 0 1 1 1 2 1 1 2 1 1 2 2 1 2 2 1 2 1 1 2 2 1 1 1 0	2 1 0 2 2 0 2 1 0 2 2 0 2 2 1 2 1 0 2 1 1 2 1 1 2 2 1 2 1 0 2 2 2 2 1 0 1 1 0 2 1 1 2 1 1 1 1 0
	WHITE (B_2)	2 2 0 2 2 1 1 1 0 1 1 1 2 1 1 2 2 1 2 2 1 2 2 2 2 2 2 2 2 1 2 2 1 2 2 1 2 1 1 2 2 1 2 2 2 2 2 2	2 2 1 2 2 0 2 2 1 1 1 1 1 1 0 1 1 1 2 1 1 1 1 1 2 2 0 2 2 2 2 2 2 2 1 1 2 1 0 2 2 1 2 2 1 2 2 1
CONTROL (A_2)	NEGRO (B_1)	2 0 0 2 1 0 2 1 0 2 1 1 2 2 2 2 2 1 2 2 1 1 1 0 2 2 1 2 2 0 2 1 1 1 1 1 2 1 0 1 1 0 2 1 1 1 1 1	1 1 0 2 2 0 1 1 0 1 0 0 2 2 0 2 2 1 2 1 0 2 2 1 2 2 1 2 1 0 2 2 2 1 1 0 1 1 1 2 2 0 2 2 0 1 1 0
	WHITE (B_2)	2 2 2 2 2 2 2 2 0 1 1 1 2 2 0 2 2 1 2 1 1 2 2 1 1 1 1 2 2 2 2 2 1 2 2 1 2 1 0 2 2 0 2 2 2 2 2 1	1 1 1 2 1 1 1 1 1 1 0 0 2 2 1 2 2 0 2 2 0 2 1 1 2 2 1 2 2 2 2 2 0 2 1 1 2 1 1 1 1 1 2 1 0 2 2 0

*For a description of the scoring treatment, see p. 59

TABLE XIV

PRETEST RAW SCORES FOR INDIVIDUAL SUBJECTS:
EACH SCORE IS A SUM OF CORRECT ATTRIBUTES

PREDOMINANTLY NEGRO SCHOOL				PREDOMINANTLY WHITE SCHOOL			
0	1	0	1	4	1	1	2
0	0	0	1	1	3	0	1
2	0	1	0	1	0	2	5
0	0	2	1	5	0	4	3
0	0	4	3	1	4	0	3
2	2	1	0	3	4	1	3
0	2	0	0	5	3	1	2
0	1	2	1	2	3	2	0
3	0	0	2	4	2	3	3
3	0	0	0	0	0	3	3
1	1	0	0	1	4	0	2
2	0	0	1	1	2	0	3
0	3	0	0	2	0	0	2
0	0	1	0	3	3	2	1
1	0	2	3	1	3	1	1
3	2	0	0	1	1	1	3
3	0	1	2	0	0	3	0
1	3	1	2	1	1	0	0
3	0	0	0	5	4	3	2
2	0	0	1	1	1	0	1
1	0	2	1	1	2	3	0
0	1	1	0	3	3	2	1
0	1	1	2	0	5	1	2
3	0	0	0	1	3	0	4